EVALUATIONS OF ENGINEERING CONTROLS FOR COTTON DUST IN OIL MILLS

FINAL REPORT

Cooperative Agreement

(No. 58-7B30-8-44)

between

Science and Education Administration
Agricultural Research - Southern Region
Post Office Box 19687
New Orleans, Louisiana 70179

and

Texas Agricultural Experiment Station
The Texas A&M University System
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I. INTRODUCTION

The Occupational Safety and Health Administration (OSHA) has promulgated a Cotton Dust Standard (OSHA, 1978) that limits worker exposure to cotton dust in the working environment in cottonseed oil mills to 0.5 mg/m^3 as measured by a vertical elutriator. This standard defines cotton dust as "dust present in the atmosphere during the handling or processing of cotton. It may contain a mixture of many substances, including ground up plant matter and other contaminants which may have accumulated during the growing, harvesting, subsequent handling, processing, or storage periods." All cottonseed oil mills have until September, 1982 to bring their facilities into compliance by use of engineering dust control systems.

A cottonseed oil mill has four main processing functions associated with oil extraction. These are (a) cleaning, (b) delintering, (c) hulling and separating, and (d) baling of linters. Each of these functional areas within an oil mill have an associated dust level (VE) of particulate having varying physical characteristics. Matlock et al., (1976) reported dust levels (VE) averaging 6.1 mg/m^3 - cleaning, 3.2 mg/m^3 - delintering, 4.3 mg/m^3 - hulling, and 1.9 mg/m^3 - baling. These readings far exceed the OSHA limit of 0.5 mg/m^3 (VE), however, these data were the result of sampling in cottonseed oil mills processing stripper harvested cottonseed. Cottonseed from stripper harvested cottons contain a much higher level of foreign matter when compared to cottonseed from spindle harvested cottons (Parnell, 1979). Dust levels in the working environments of cottonseed oil mills are affected by dust levels in the seed (Parnell, 1977).

In setting standards, the secretary of labor is required to give due regard to the question of feasibility. Section 6(b)(5) of the Occupational Safety and Health Act mandates that the Secretary shall set a standard which most adequately assures employees' safety and health "to the extent feasible, on the basis of the best available evidence." In the standard it was stated [1] "OSHA believes that achievement of a 500 $\mu g/m^3$ permissible exposure limit is technologically feasible for all non-textile segments of the cotton industry" (OSHA, 1978).

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[1] Page 27362 - OSHA Cotton Dust Standard

In discussions with industry engineers, it was hypothesized that a number of dust control systems referred to as "engineering controls" were being used by different cottonseed oil mills with success. However, no one had documented these various dust control systems to date. This project was directed at reviewing the existing dust control systems in the cottonseed oil mill industry and locating engineering controls that could be used in a detailed study. The detailed study would involve documenting the level of dust control with the vertical elutriator as the primary measuring instrument and developing a design manual, to be used by the cottonseed oil mill industry to comply with the OSHA regulations. The detailed study has been funded to Texas Tech University under the direction of Dr. Robert Bethea.

The Department of Agricultural Engineering at Texas A&M University in cooperation with the United States Department of Agriculture, Science and Education Administration, Southern Regional Research Center (USDA, SEA, SRRC) initiated this survey of existing dust control systems in cottonseed oil mills. The objective of this survey was to visit mills currently utilizing dust controls and evaluate their effectiveness. The effectiveness was evaluated with the use of special air samplers, that allowed for a variety of sampling schemes, in addition to the use of vertical elutriators. A sub-objective of this study was to determine the dust content in cottonseed at various stages in the mill and correlate this dust content to the dust found in the working environment.

II. PROCEDURE

Field studies were made at 10 oil mills in Texas, Arizona, and California. The oil mills in Arizona and California were processing seed from spindle harvested cotton, and the Texas oil mills were processing cottonseed from stripper harvested cotton. This study included a variety of mill sizes. Each mill was using technology that seemed to have value relative to dust control. Several equipment manufacturers were contacted with regard to new approaches in oil mill design and equipment modifications that would lower dust levels.

At each operating oil mill 1.5 to 2.5 kg samples of cottonseed were taken in the process stream and returned to Texas A&M University for analysis. Dust level readings with two special samplers were taken and recorded. These samplers were (a) a GCA Corporation[2] (GCA) respirable dust monitor and (b) a Thermo-Systems, Inc. (TSI) respirable aerosol monitor. The GCA and TSI samplers required 4 and 2 minutes, respectively, to obtain a measure of dust concentration in units of mg/m^3. These samplers allowed for a flexible and comprehensive sampling scheme at oil mills. Thus more samples at more locations were able to be taken in a shorter amount of time than could have been achieved by using vertical elutriators. With data reported by Hersh et al., (1979), the GCA and TSI readings were converted to equivalent vertical elutriator readings. Although Hersh's data were obtained in textile mills, it was thought that it would give a sufficient approximation for oil mill dust. In addition, four vertical elutriators were used in sampling Mills H, I, and J.

Several major pieces of information were desired from the cottonseed samples. First it was necessary to determine the concentration of dust in the cottonseed samples and to establish any patterns of variation which may exist between the various sampling points and between similar stations for the different mills. Second it was desired to know some physical characteristics, particularly the particle size distribution, of the cottonseed dust.

To determine the concentration of dust in the cottonseed, a tumbler mechanism (under vacuum) was used to extract particles less than one hundred

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[2] Names of companies or commercial products are given solely for the purpose of providing specific information; their mention does not imply recommendation or endorsement by the authors over others not mentioned.

microns from a cottonseed sample. The extracted dust was trapped on a pre-weighed glass filter which was then reweighed. With the dust weight thus determined, and the seed sample weight known, a dust concentration (in mg dust/gm seed) could be calculated for each cottonseed sample. Three repetitions were run for each sample, when possible, and an average concentration at each station was determined.

A statistical analysis procedure was employed to compare similar stations for the different mills. Computer analysis was employed for Duncan's Multiple Range Test with the stations being the variable. Mills showing no significant difference in concentration for similar sampling stations were grouped together.

The particle size distribution (PSD) for the collected dust samples was determined with use of a Coulter Counter. Analysis was made of one of the exposed filters from each sampling station, with three repetitions run for each filter analyzed. The data was recorded as percent cumulative volume versus particle diameter. Analysis of the data obtained for each sampling station yielded several physical parameters of interest. These included the average mass mediam diameter (MMD) for the sample dust, the geometric standard deviation (σg), and the percentage of the sample dust which has a diameter less than fifteen microns and ten microns. By multiplying the percentage of dust less than a given diameter by the concentration of dust in the seed sample, the concentration of dust less than the given diameter was determined.

III. RESULTS

Figure 1 shows a flow diagram for the cottonseed delinting process. Seed samples were taken between the processing stations and labeled as indicated by the diagram. Bar charts representing the concentration of cottonseed dust at the various sampling stations are shown in Figures 2-12. Lines representing the range of the 95% confidence interval are included on each bar. Included in Appendix A are histograms for each station sampled at each mill showing the mass concentration for various particle size ranges.

In making comparisons between the different mills for similar stations, it is important to note that Mill C, Mill D, Mill E, and Mill F handle picker harvested cottonseed. Also Mill B, Mill G, and Mill H are the same mill on different days. These samples were treated independently as different mills. Table 1 is a complete list of the mills sampled and the stations at each mill where seed was collected for sampling.

It is immediately apparent from the graphs that the stripper cottonseed has a much higher dust content than the picker cottonseed when it arrives at the mill. At station P_0, Mill B, with a dust concentration of 2.6226 mg/gm, had the dustiest seed, while Mill C, with 0.1752 mg/gm was the cleanest. However in comparing Figure 8 with Figure 13 for station P_0, the wide variation of dust content possible at the same mill is seen. Samples from the same station at the same mill on different days ranged from 0.5043 mg/gm to 2.6226 mg/gm, an increase of over four hundred percent.

For mills handling picker cottonseed, the levels of dust in the cottonseed appear to be similar. This observation is supported by the results of the Duncan's Multiple Range Test, Tables 2 and 3. For uncleaned seed, station P_0, the concentration of cottonseed dust for mills handling picker cottonseed was found not to be significantly different. With the exception of Mill D, which showed an increase from 0.2238 to 0.3148 mg/gm (dust less than 100 microns), the levels of dust in the cottonseed decreased after the seed had been cleaned (P_2).

In seven of the ten mills the concentration of dust in the cottonseed was higher after completion of the delinting process that it was after the seed had been cleaned. This suggests that the process itself creates some

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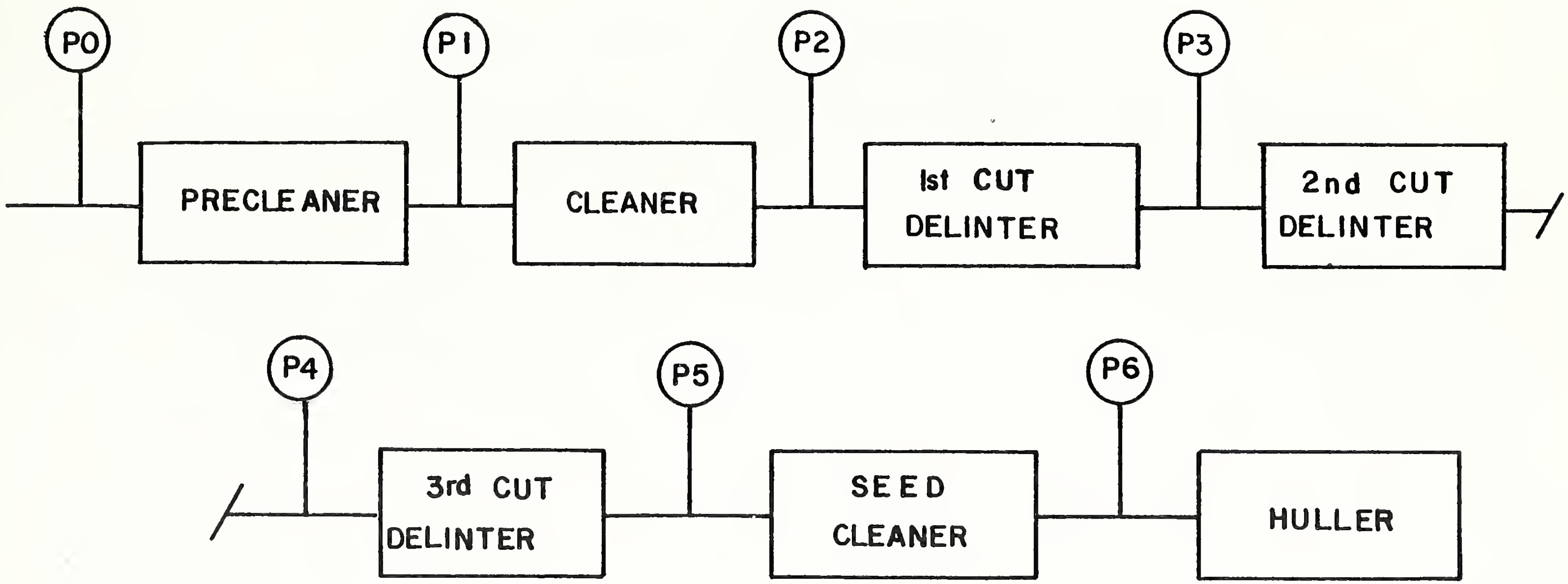


FIGURE 1. Flow diagram of process stream in typical cottonseed oil mill showing locations of sampling points P_0, P_1, P_2, P_3, P_4, P_5, and P_6.

TABLE 1.

LIST OF MILLS STUDIED

MILL A - Abilene Acco (P_0, P_2, P_3, P_4) Stripper Cotton

Mill B - Sweetwater (P_0, P_2, P_3, P_4, P_5) Stripper Cotton

Mill C - Phoenix Acco (P_0, P_2, P_3, P_4) Picker Cotton

Mill D - Boswell (P_0, P_2, P_3, P_4, P_5) Picker Cotton

Mill E - Ranchers (P_0, P_2, P_3, P_4, P_5) Picker Cotton

Mill F - Fresno Producers (P_0, P_2, P_3, P_4) Picker Cotton

Mill G - Sweetwater (P_0, P_3, P_4, P_5) Stripper Cotton

Mill H - Sweetwater (P_0, P_1, P_2, P_3, P_4) Stripper Cotton

Mill I - Plains Coop, Lubbock (P_0, P_2, P_3, P_4, P_5) Stripper Cotton

Mill J - Lubbock Acco (P_0, P_2, P_3, P_4) Stripper Cotton

Mill K - Lamesa (P_0, P_1, P_2, P_3, P_4) Stripper Cotton

Mill L - Plainview (Under Renovation)

COTTONSEED SAMPLING STATION KEY

P_0 - Uncleaned seed

P_1 - After pre-cleaning

P_2 - After cleaning

P_3 - After first cut delinters

P_4 - After second cut delinters

P_5 - After third cut delinters

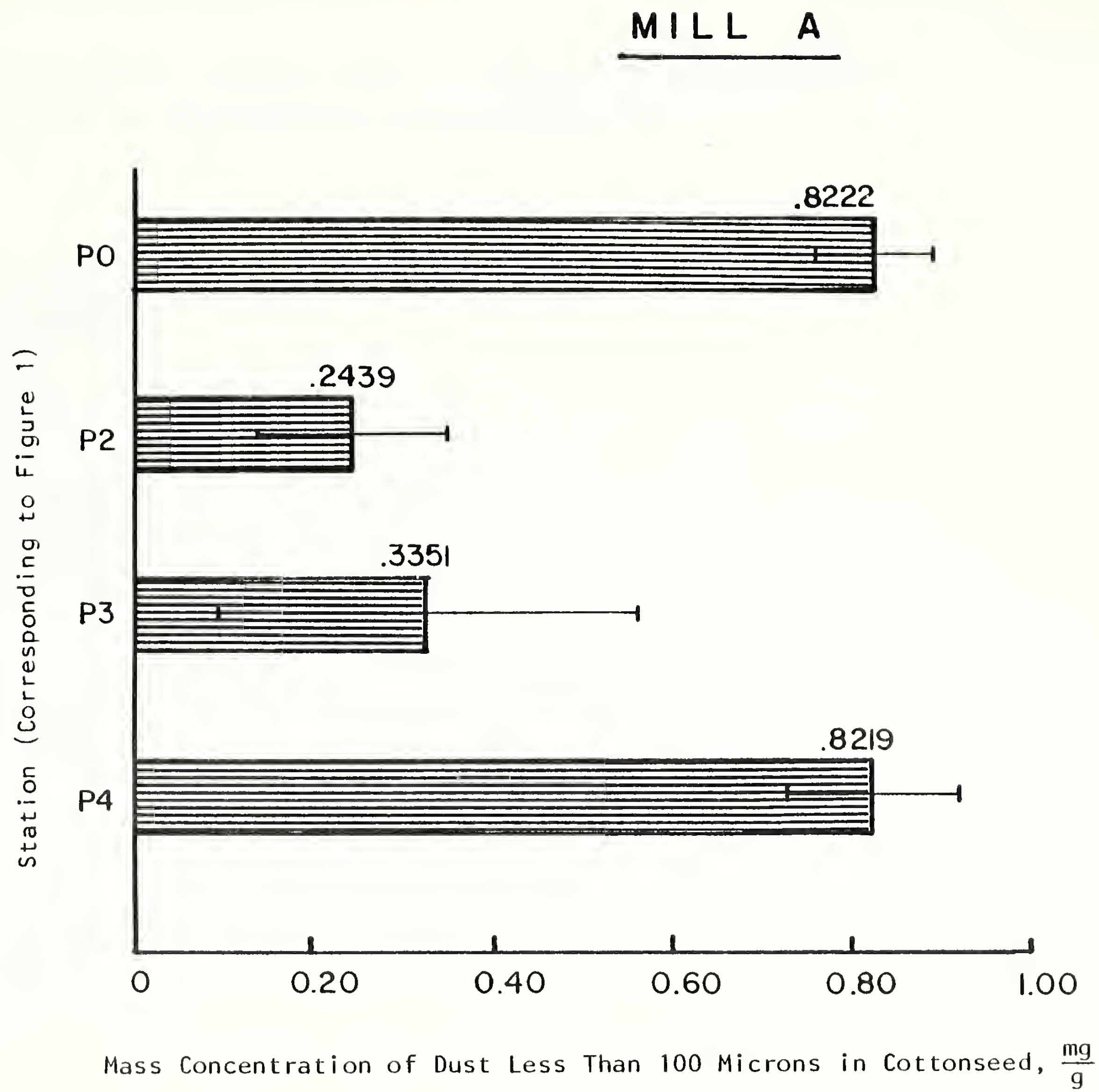

MILL A
Station (Corresponding to Figure 1)
P0
P2
P3
P4
.8222
.2439
.3351
.8219
0
0.20
0.40
0.60
0.80
1.00
Mass Concentration of Dust Less Than 100 Microns in Cottonseed, mg/g

FIGURE 2.

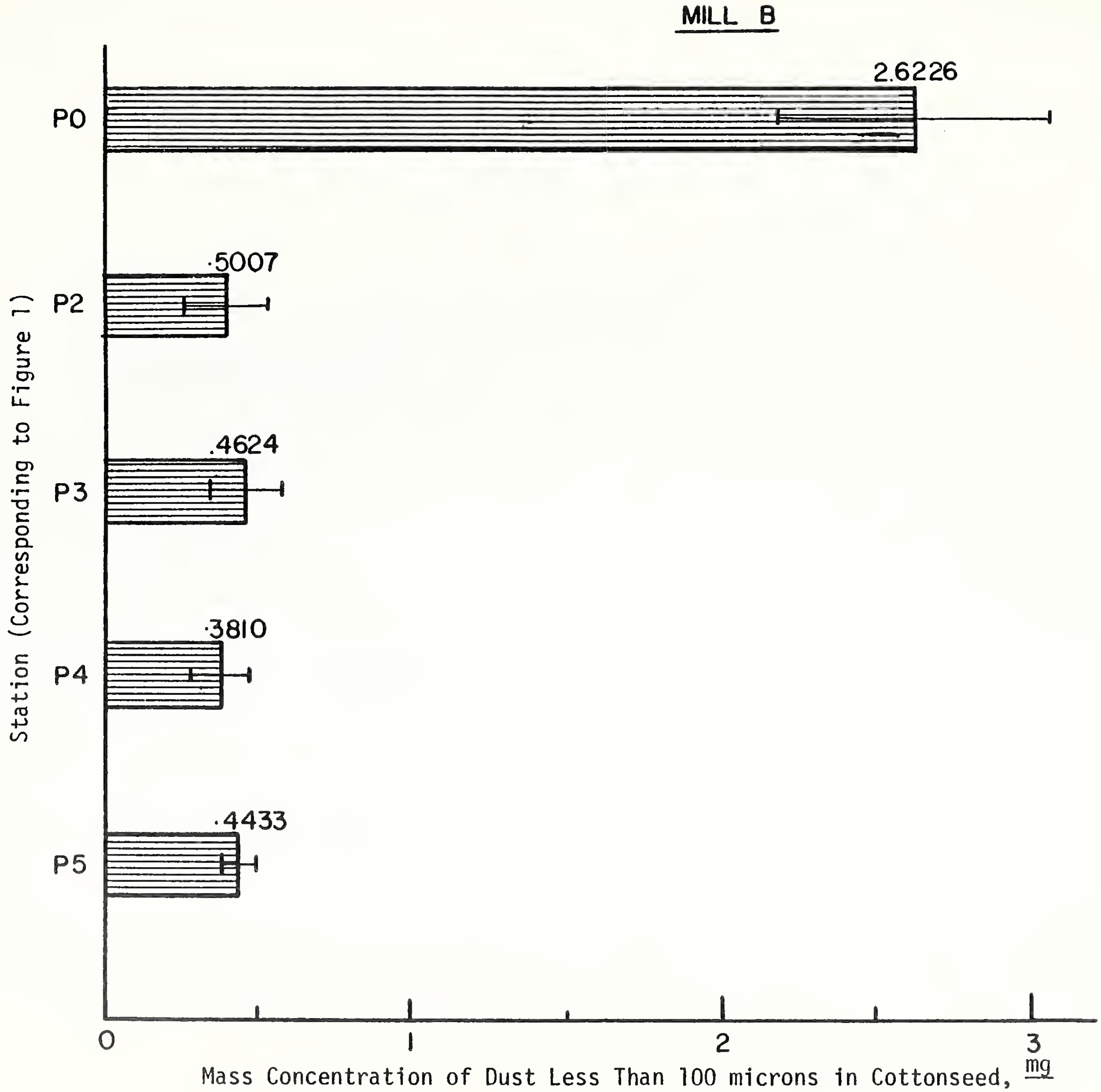

MILL B
2.6226
.5007
.4624
.3810
.4433
P0
P2
P3
P4
P5
Station (Corresponding to Figure 1)
0
1
2
3
Mass Concentration of Dust Less Than 100 microns in Cottonseed, mg

FIGURE 3.

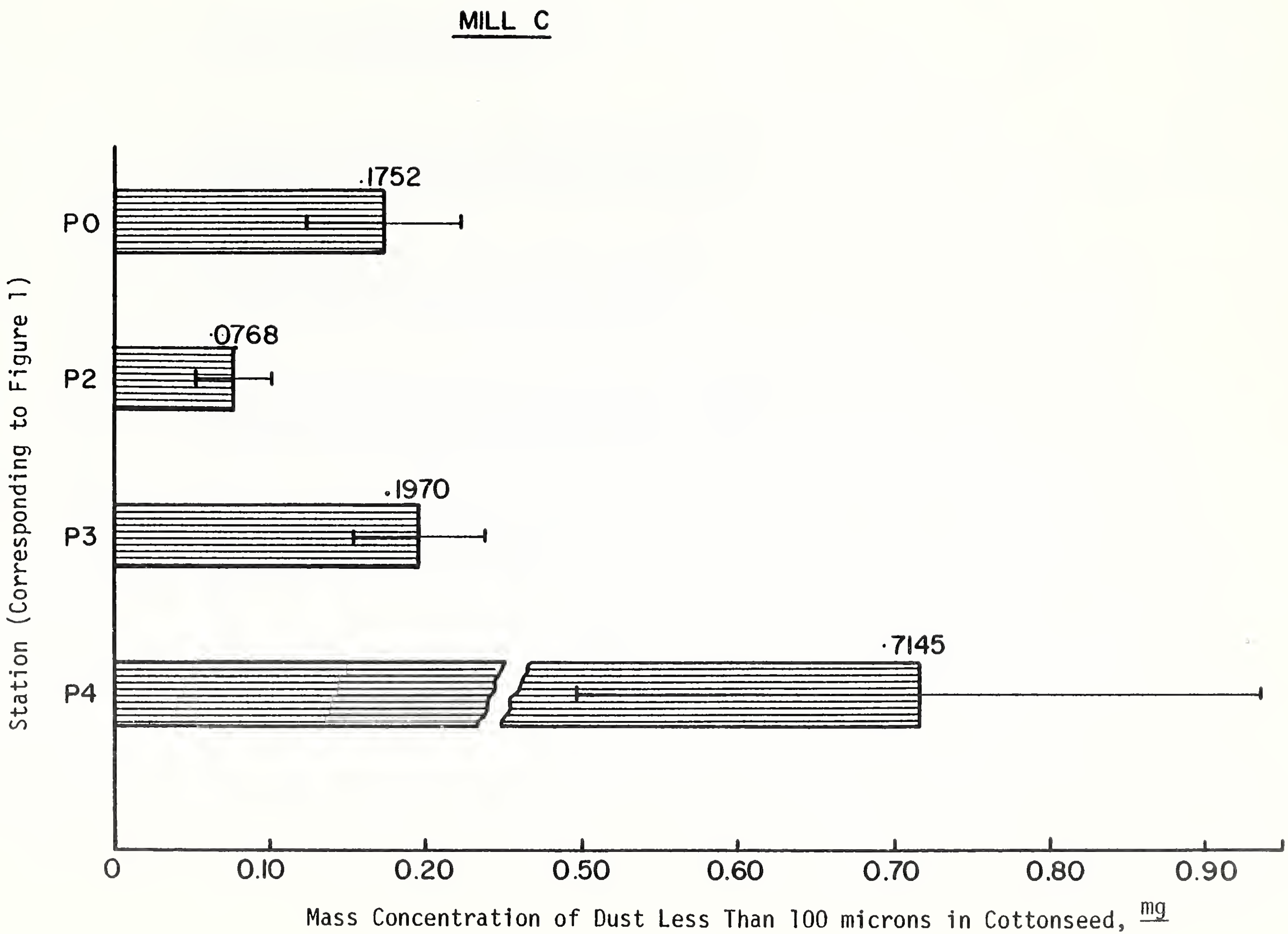

MILL C
.1752
.0768
.1970
.7145
P0
P2
P3
P4
Station (Corresponding to Figure 1)
0
0.10
0.20
0.50
0.60
0.70
0.80
0.90
Mass Concentration of Dust Less Than 100 microns in Cottonseed, mg

FIGURE 4.

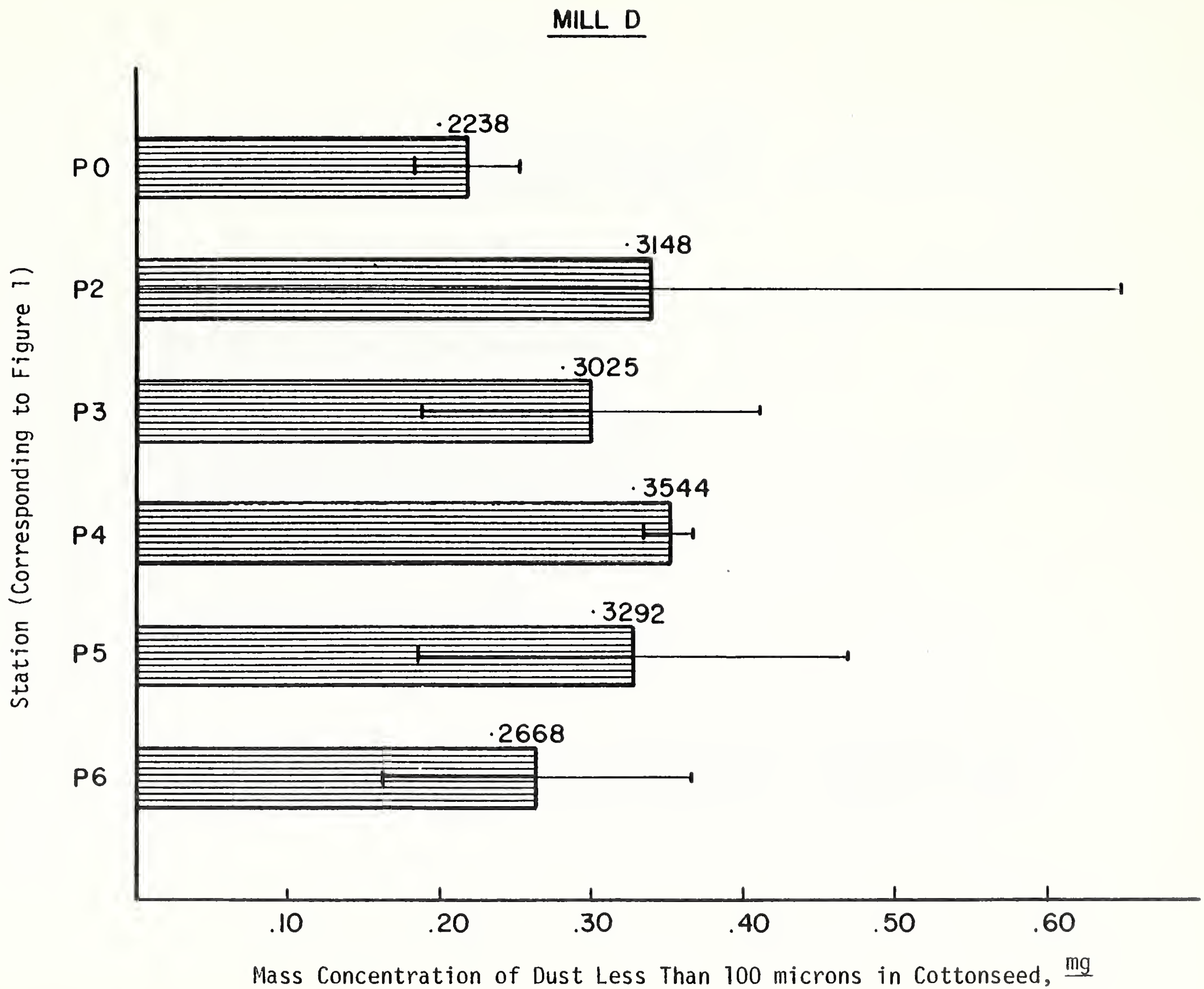

MILL D
Station (Corresponding to Figure 1)
P0
P2
P3
P4
P5
P6
.2238
.3148
.3025
.3544
.3292
.2668
.10
.20
.30
.40
.50
.60
Mass Concentration of Dust Less Than 100 microns in Cottonseed, mg

FIGURE 5.

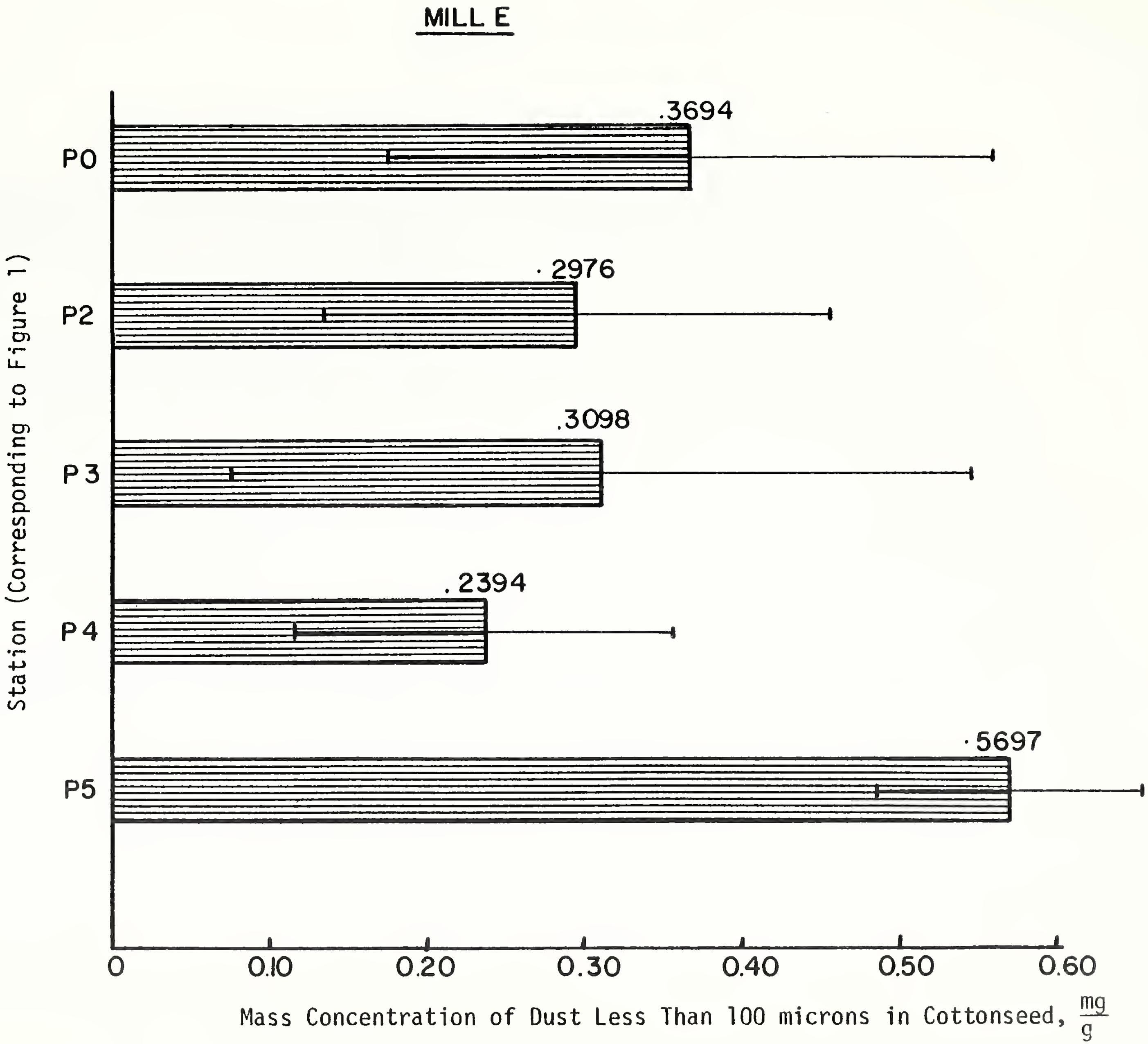

MILL E
Station (Corresponding to Figure 1)
P0
P2
P3
P4
P5
.3694
.2976
.3098
.2394
.5697
0
0.10
0.20
0.30
0.40
0.50
0.60
Mass Concentration of Dust Less Than 100 microns in Cottonseed, mg/g

FIGURE 6.

MILL F

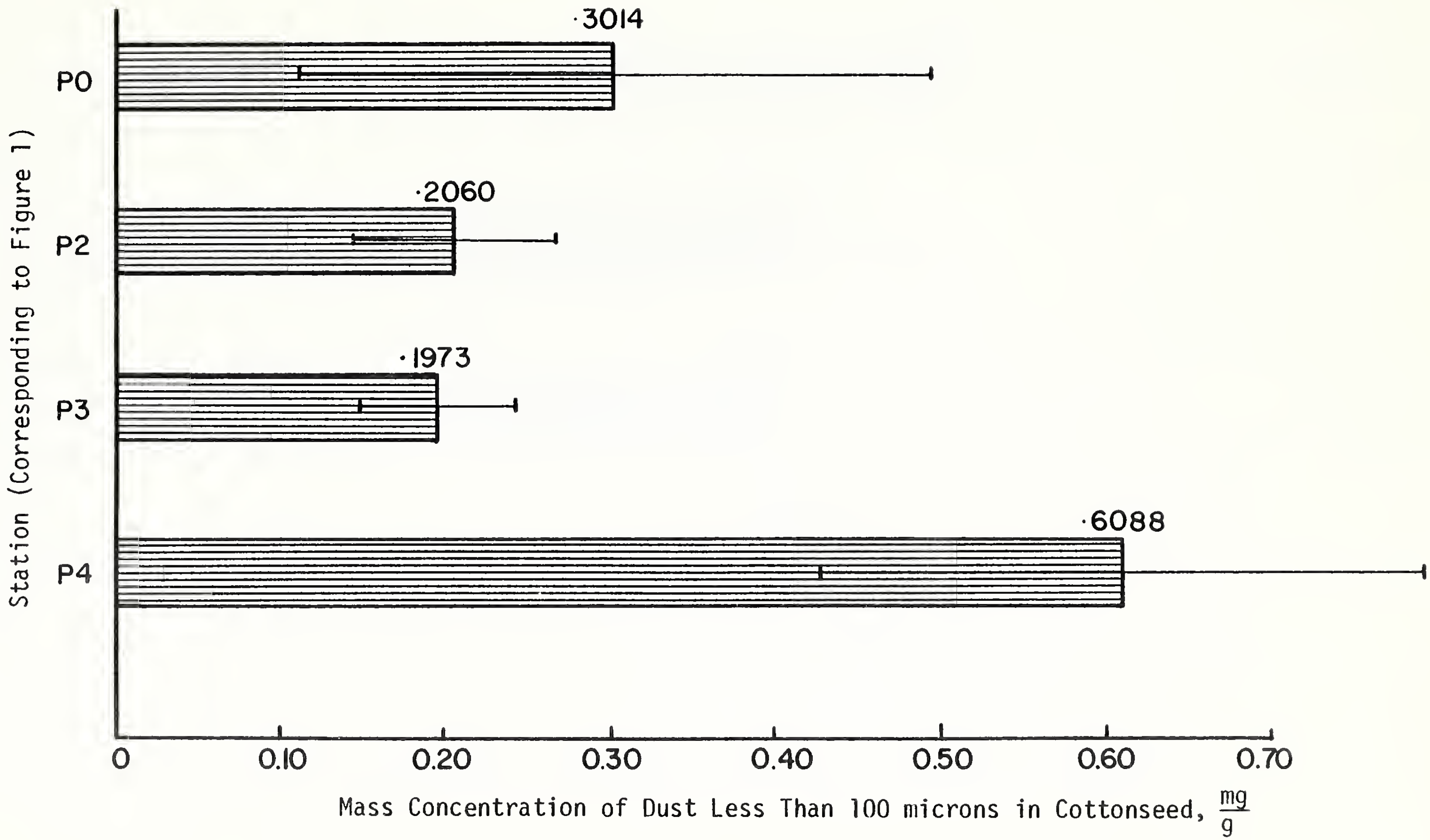


FIGURE 7.

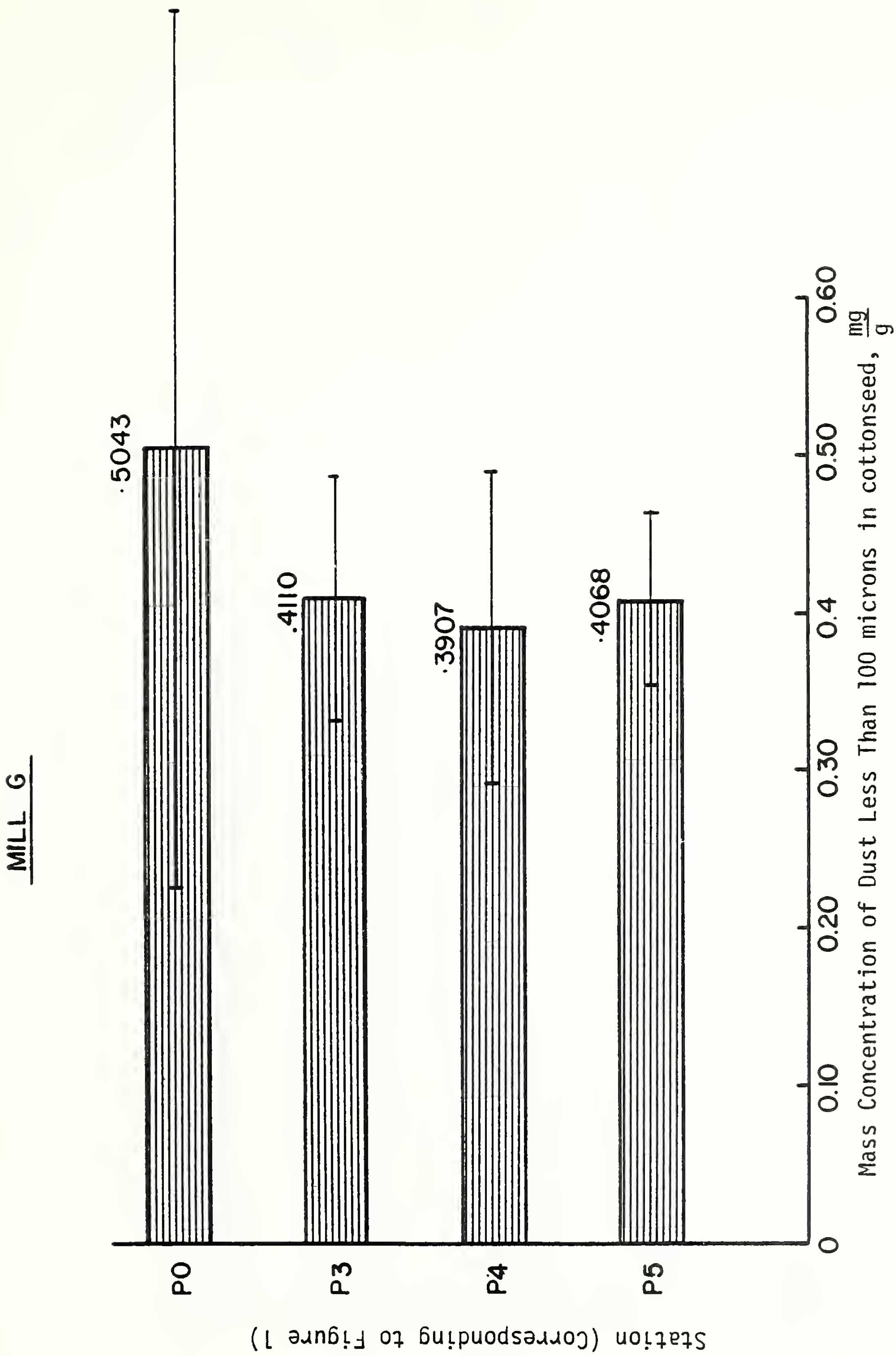

MILL G
.5043
.4110
.3907
.4068
P0
P3
P4
P5
Station (Corresponding to Figure 1)
0
0.10
0.20
0.30
0.4
0.50
0.60
Mass Concentration of Dust Less Than 100 microns in cottonseed, mg/g

FIGURE 8.

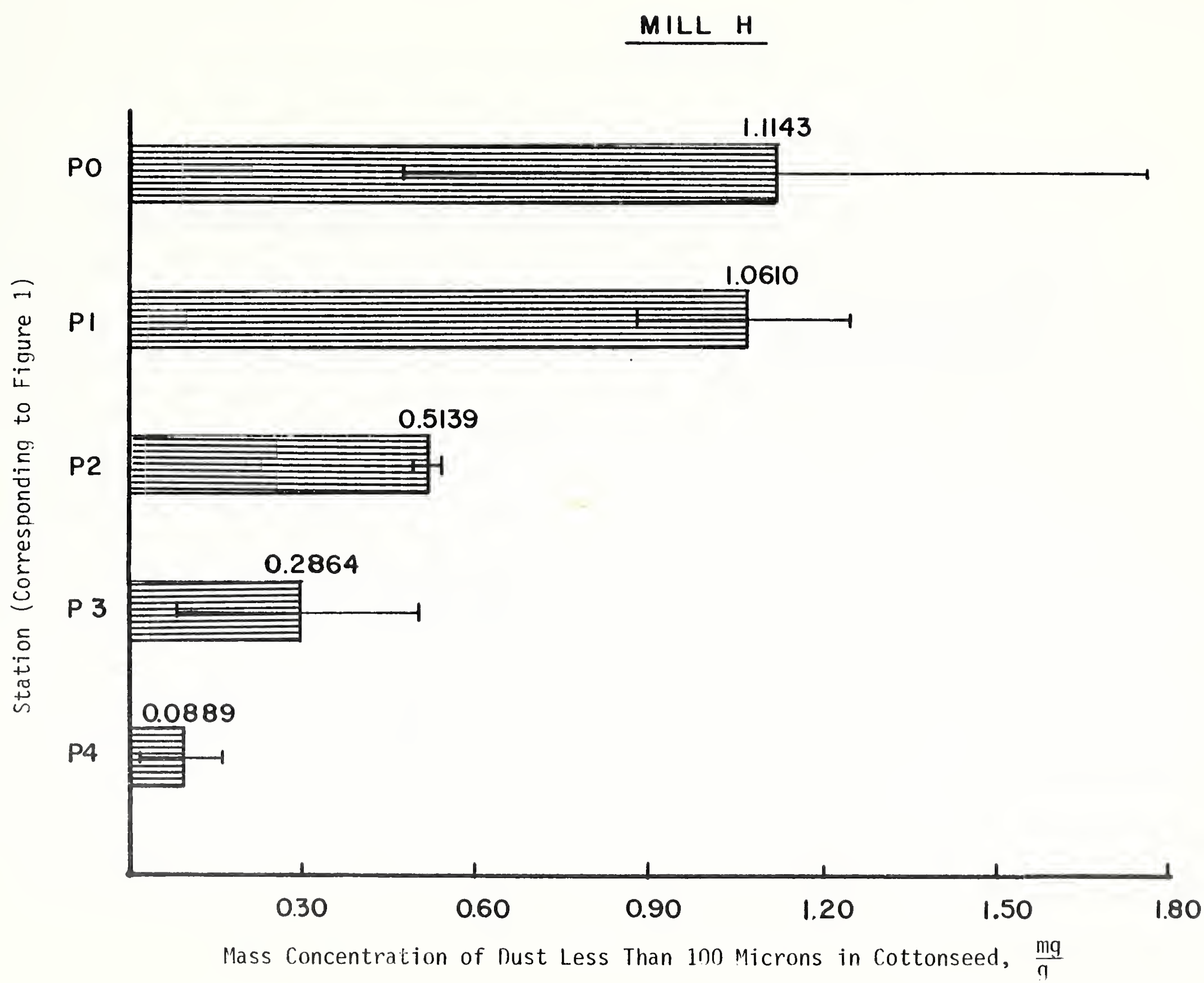

MILL H
P0
P1
P2
P 3
P4
1.1143
1.0610
0.5139
0.2864
0.0889
0.30
0.60
0.90
1.20
1.50
1.80
Station (Corresponding to Figure 1)
Mass Concentration of Dust Less Than 100 Microns in Cottonseed, $\frac{mg}{g}$

FIGURE 9.

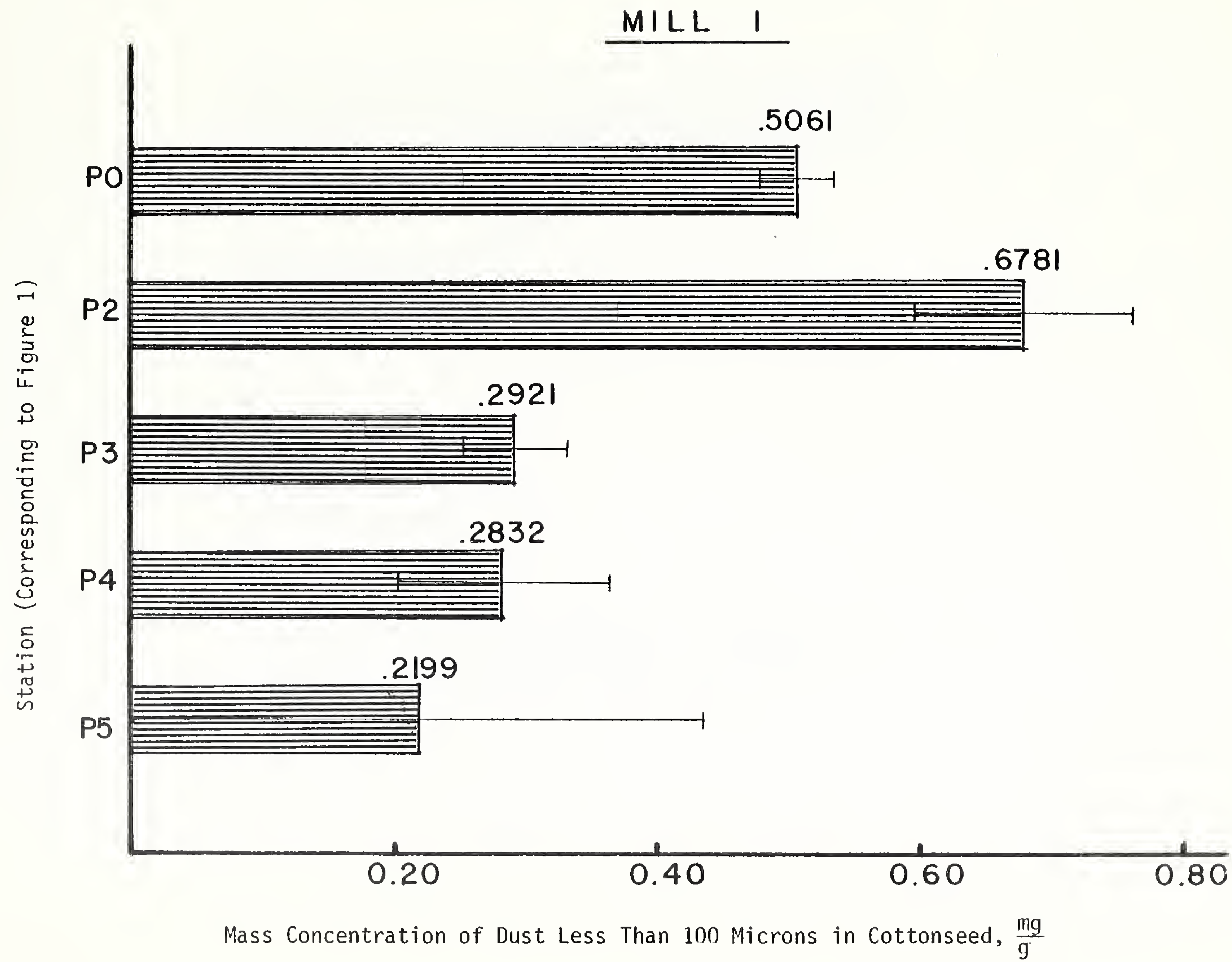

MILL I
Station (Corresponding to Figure 1)
P0
P2
P3
P4
P5
.5061
.6781
.2921
.2832
.2199
0.20
0.40
0.60
0.80
Mass Concentration of Dust Less Than 100 Microns in Cottonseed, mg/g

FIGURE 10.

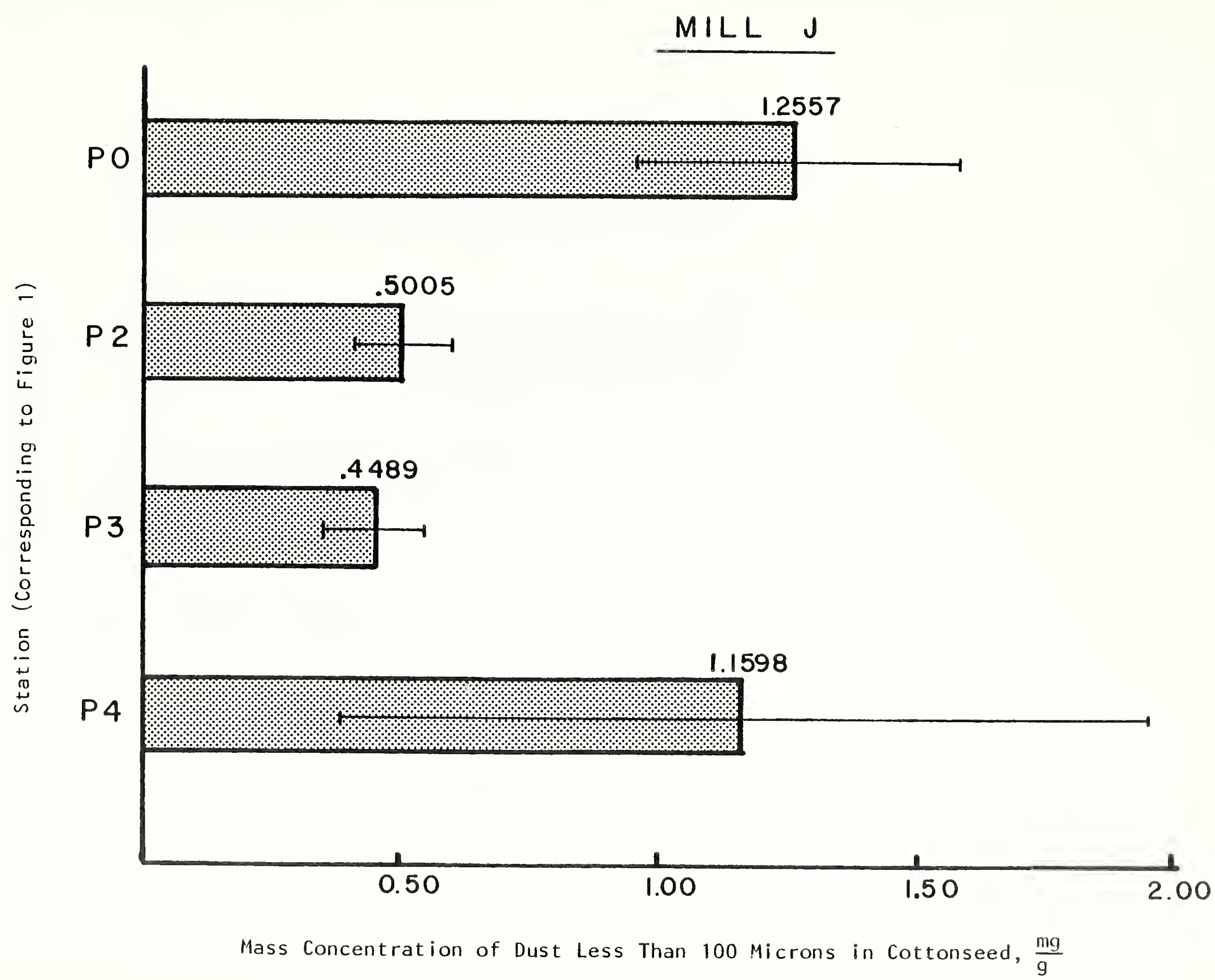

MILL J
1.2557
.5005
.4489
1.1598
P0
P2
P3
P4
Station (Corresponding to Figure 1)
0.50
1.00
1.50
2.00
Mass Concentration of Dust Less Than 100 Microns in Cottonseed, mg/g

FIGURE 11.

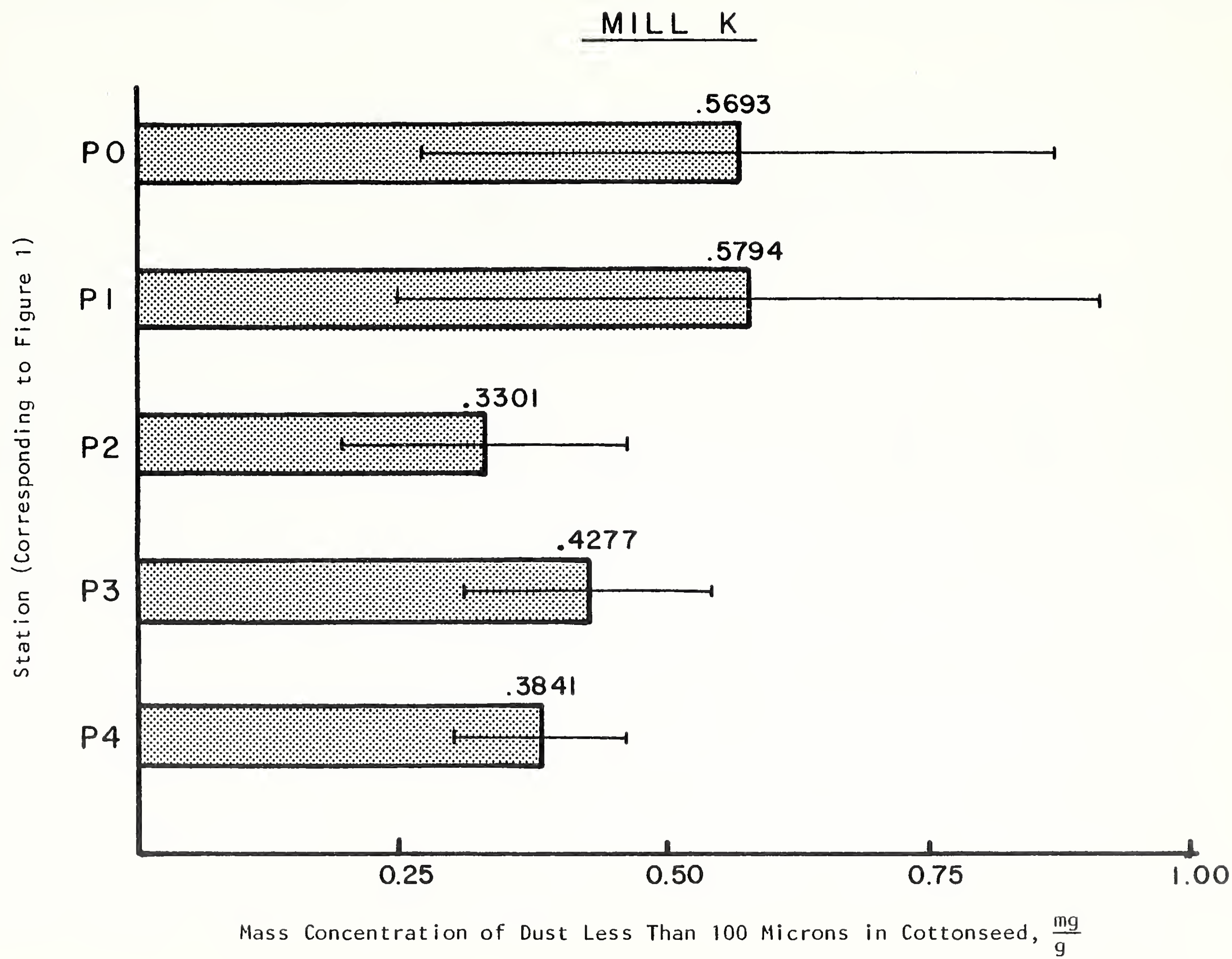

MILL K
P0
P1
P2
P3
P4
.5693
.5794
.3301
.4277
.3841
0.25
0.50
0.75
1.00
Station (Corresponding to Figure 1)
Mass Concentration of Dust Less Than 100 Microns in Cottonseed, mg/g

FIGURE 12.

TABLE 2.

Results of Duncan's Multiple Range Test on Dust Less than 100 Microns in Seed at the 95% Confidence Level

Station											
P_0	.1752 Mill C	.2238 Mill D	.3014 Mill F	.3694 Mill E	.5043 Mill G	.5066 Mill I	.5860 Mill K	.8223 Mill A	1.1168 Mill H	1.2611 Mill J	2.6222 Mill B
P_1	.6648 Mill K	1.0429 Mill H									
P_2	.0769 Mill C	.2060 Mill F	.2439 Mill A	.2801 Mill K	.2976 Mill E	.3148 Mill D	.4776 Mill J	.5007 Mill B	.5096 Mill H	.6795 Mill I	
P_3	.1970 Mill C	.1973 Mill F	.2545 Mill H	.2935 Mill I	.3025 Mill D	.3098 Mill E	.3351 Mill A	.4110 Mill G	.4488 Mill J	.4548 Mill K	.4624 Mill B
P_4	.0403 Mill H	.2394 Mill E	.2622 Mill I	.3544 Mill D	.3810 Mill B	.3907 Mill G	.3948 Mill K	.6088 Mill F	.7145 Mill C	.8219 Mill A	1.3169 Mill J
P_5	.2861 Mill I	.3293 Mill D	.4068 Mill G	.4433 Mill B	.5697 Mill E						

Any two means not underscored by the same line are significantly different.

TABLE 3.

Results of Duncan's Multiple Range Test on Dust Less than 10 Microns in Seed at the 95% Confidence Level

Station											
P_0	.1610	.1766	.2270	.2904	.3339	.3999	.4454	.5205	.6968	.7857	1.1574
	Mill C	Mill D	Mill F	Mill E	Mill I	Mill G	Mill K	Mill A	Mill H	Mill J	Mill B
P_1	.4492	.6800									
	Mill K	Mill H									
P_2	.0632	.1669	.1868	.2201	.2254	.2482	.3262	.3560	.4064	.4072	
	Mill C	Mill F	Mill A	Mill K	Mill D	Mill E	Mill J	Mill B	Mill I	Mill H	
P_3	.1596	.1636	.1764	.2055	.2375	.2506	.2801	.3182	.3317	.3317	.3583
	Mill C	Mill F	Mill H	Mill I	Mill D	Mill E	Mill A	Mill J	Mill G	Mill B	Mill K
P_4	.0306	.1906	.1968	.2787	.2827	.2842	.2903	.3817	.5695	.6978	.8125
	Mill H	Mill I	Mill E	Mill K	Mill B	Mill D	Mill G	Mill F	Mill C	Mill A	Mill J
P_5	.2029	.2690	.3441	.3618	.4256						
	Mill I	Mill D	Mill G	Mill B	Mill E						

Any two means not underscored by the same line are significantly different.

of the cottonseed dust (one mill did not have an after cleaning sample).

The physical characteristics of the cottonseed dust have been summarized in Tables 4 and 5 and in Appendix A. Table 4 includes many of the paramaters of special interest to this research. Comparison of the mass mean diameter (MMD) for uncleaned seed (Station P_0) shows the stripper cottonseed samples generally had much higher MMD's than the picker cottonseed. The average MMD for picker cottonseed samples was 5.815 microns while the average MMD for stripper cottonseed samples was 7.471 microns. However, as the processing cycles advanced, the values of the MMD for all mills became more similar and the distinction between picker or stripper cottonseed according to MMD was not apparent. Appendix A contains data that depict trends in the amounts of dust present in cottonseed at each sampling station. Each graph in this appendix plots the mass concentration of dust in the seed versus the particle size as determined by the Coulter Counter analysis. These graphs substantiate the trends seen in Table 2 discussed above.

Also included in Table 4 are the concentrations of cottonseed dust less than 15 microns and less than 10 microns. Table 5 reports these concentrations on a percentage basis. Analysis of these figures shows that as the cottonseed was processed, the percentage of udst for a given particle diameter changed very little for the picker cottonseed. Conversely, as the stripper cottonseed was processed, more dramatic increases (over 30% for Mill B less than 10 microns) in the amount of the smaller diameter dust particles were observed. These findings suggest a higher stability for picker harvested cottonseed compared to stripper harvested seed.

Tables 6 through 14 show the results of sampling conducted in oil mills with the GCA and TSI air samplers. Equivalent vertical elutirator readings are given using Hersh's equations. Table 2 is the reference for the mills. As with seed samples, Mill B and Mill G were the same mill sampled at different times, but were treated as two independent mills.

According to the GCA data, only the bale room of Mill B, the cleaning and bale rooms of Mill F, the bale room of Mill G, and the bale room of H presently meet the OSHA standard of 0.5 mg/m^3. The TSI data indicate that the hulling and separating areas of Mills H and I might also comply. However, these data are not truly indicative of the respirable dust concentrations. Only thorough sampling using VE's according to the OSHA standard can yield

TABLE 4.

Physical Characteristics of Cottonseed Dust

Station	Mill	MMD μm	σg	Conc. $\frac{mg}{gm}$ (with 95% C.I.)	LT 15 μm $\frac{mg}{gm}$	LT 10 μm $\frac{mg}{gm}$
P_0	A	7.691	2.436	0.8222±0.4347	0.6712	0.438
	B	10.210	2.362	2.6226±0.4347	1.7114	1.2891
	C	5.421	2.065	0.1752±0.0538	0.1715	0.1381
	D	5.826	2.045	0.2238±0.0416	0.2128	0.1695
	E	5.729	2.088	0.3694±0.1928	0.3496	0.2801
	F	6.285	2.144	0.3014±0.1919	0.2680	0.2133
	G	5.737	2.221	0.5043±0.2793	0.4594	0.3719
	H	7.741	2.381	1.1143±0.6416	0.8472	0.6740
	I	7.172	2.440	0.5061±0.0303	0.3960	0.3174
	J	7.756	2.409	1.2557±0.3052	0.9493	0.7517
	K	5.987	2.259	0.5693±0.2974	0.5036	0.4069
P_1	H	7.253	2.261	1.0610±0.1798	0.8531	0.6731
	K	7.091	2.464	0.5794±0.3312	0.4539	0.3650
P_2	A	6.087	2.211	0.2439±0.1097	0.2166	0.1746
	B	6.630	2.244	0.5007±0.2280	0.4229	0.3371
	C	4.491	1.752	0.0768±0.0211	0.0768	0.0759
	D	6.609	2.199	0.3148±0.3262	0.2692	0.2139
	E	5.403	2.017	0.2976±0.1596	0.2966	0.2399
	F	5.629	2.035	0.2060±0.0645	0.1999	0.1598
	H	6.308	2.225	0.5139±0.0165	0.4469	0.3580
	I	8.115	2.467	0.6781±0.0838	0.4965	0.3926
	J	7.048	2.390	0.5005±0.0913	0.3990	0.3189
	K	5.788	2.075	0.3301±0.1344	0.3117	0.2492

TABLE 4. (cont.)

Station	Mill	MMD μm	σg	Conc. $\frac{mg}{gm}$ (with 95% C.I.)	LT 15 μm $\frac{mg}{gm}$	LT 10 μm $\frac{mg}{gm}$
P_3	A	5.299	2.056	0.3351±0.2246	0.3316	0.2689
	B	5.541	2.025	0.4624±0.1824	0.4537	0.3631
	C	5.607	2.048	0.1970±0.0426	0.1907	0.1527
	D	5.898	2.190	0.3025±0.1179	0.2741	0.2207
	E	5.635	2.044	0.3098±0.2336	0.2997	0.2397
	F	5.478	2.019	0.1973±0.0499	0.1952	0.1563
	G	5.647	2.044	0.4110±0.0783	0.3972	0.3176
	H	6.842	2.385	0.2864±0.2062	0.2315	0.1859
	I	6.660	2.463	0.2921±0.0414	0.2358	0.1910
	J	6.685	2.438	0.4489±0.0918	0.3634	0.2937
	K	5.713	2.241	0.4277±0.1150	0.3885	0.3151
P_4	A	5.407	1.979	0.8219±0.0934	0.8134	0.6189
	B	6.239	2.034	0.3810±0.1401	0.3511	0.2768
	C	5.763	2.034	0.7145±0.2199	0.6858	0.5466
	D	5.624	2.072	0.3544±0.0198	0.3400	0.2727
	E	5.440	2.042	0.2394±0.1377	0.2357	0.1893
	F	7.717	2.456	0.6088±0.1837	0.4581	0.3643
	G	6.361	2.216	0.3907±0.0981	0.3370	0.2575
	H	6.324	2.380	0.0707±0.1755	0.0617	0.0493
	I	6.607	2.411	0.2832±0.0829	0.2325	0.1875
	J	8.332	2.584	1.1598±0.7794	0.8250	0.6560
	K	6.920	2.174	0.3841±0.0805	0.3226	0.2542

TABLE 4. (cont.)

Station	Mill	MMD μm	σg	Conc. $\frac{mg}{gm}$ (with 95% C.I.)	LT 15 μm $\frac{mg}{gm}$	LT 10 μm $\frac{mg}{gm}$
P_5	B	5.434	1.991	0.4433±0.0762	0.4433	0.3558
	D	5.536	2.041	0.3293±0.1437	0.3216	0.2577
	E	6.325	2.193	0.5697±0.0861	0.4986	0.3982
	G	5.163	2.061	0.4068±0.0512	0.4068	0.3303
	I	6.792	2.374	0.2199±0.2169	0.1787	0.1435

NOTE: Mill A, Mill B, and Mill G handle stripper cottonseed.

TABLE 5.

Percentage of Dust Less Than 15 Microns

Station	Mill A	Mill B	Mill C	Mill D	Mill E	Mill F	Mill G	Mill H	Mill I	Mill J	Mill K
P_0	75.61	65.26	97.89	95.08	94.62	88.93	91.10	76.03	78.24	75.60	88.46
P_1	---	---	---	---	---	---	---	80.40	---	---	78.35
P_2	88.79	84.45	100.00	85.50	99.66	97.06	---	86.96	73.22	79.74	94.41
P_3	99.27	98.14	96.82	90.63	96.73	98.92	96.64	80.83	80.73	80.96	90.84
P_4	98.96	92.16	95.99	94.94	98.45	75.24	86.26	87.33	82.10	71.13	84.00
P_5	---	100.00	---	97.69	87.52	---	100.00	---	81.27	---	---

Percentage of Dust Less Than 10 Microns

Station	Mill A	Mill B	Mill C	Mill D	Mill E	Mill F	Mill G	Mill H	Mill I	Mill J	Mill K
P_0	60.06	49.16	78.81	75.75	75.82	70.78	73.76	60.49	62.70	59.86	71.48
P_1	---	---	---	---	---	---	---	63.52	---	---	63.00
P_2	71.35	67.33	98.72	67.93	79.94	77.59	---	69.66	57.90	63.72	75.50
P_3	80.07	78.54	77.53	72.98	77.37	79.23	77.28	64.91	65.40	65.43	73.68
P_4	80.75	72.67	76.50	76.95	79.08	59.84	69.40	69.78	66.21	56.56	66.18
P_5	---	80.22	---	78.29	69.90	---	81.40	---	65.26	---	---

TABLE 6. DUST LEVELS MEASURED WITH A GCA SAMPLER IN MILL A.

AREA	GCA	EQUIVALENT VE
Outside	0.58	1.12
Cleaning &	1.01	1.95
Lintering	0.65	1.25
	1.07	2.06
		1.75 = AVG.
Hulling	1.80	3.47
Baling	1.54	2.97
	1.01	1.95
		2.46 = AVG.
Outside of Baling	0.04	0.77
Office	0.08	0.16

All measurements are in units of mg/m^3

TABLE 7. DUST LEVELS MEASURED WITH A GCA SAMPLER IN MILL B.

AREA	GCA	EQUIVALENT VE
Cleaning	0.77	1.48
	1.91	3.68
		2.58 = AVG.
Lintering	0.71	1.37
	0.97	1.87
	0.74	1.43
	0.78	1.50
		1.54 = AVG.
Hulling & Separating	0.84	1.62
	0.28	0.54
	0.23	0.45
		0.87 = AVG.
Baling	0.10	0.20
	0.02	0.04
		0.12 = AVG.

All measurements are in units of mg/m^3

TABLE 8. DUST LEVELS MEASURED WITH A GCA SAMPLER IN MILL C.

AREA	GCA	EQUIVALENT VE
Cleaning	0.71	1.37
	1.11	2.14
		1.76 = AVG.
Lintering	1.09	2.10
	1.34	2.58
	1.24	2.39
		2.36 = AVG.
Hulling & Separating	1.65	3.18
	2.02	3.89
	0.76	1.47
	1.09	2.10
		2.66 = AVG.
Bale Room	0.28	0.54
	0.50	0.97
		0.76 = AVG.

All measurements are in units of mg/m^3

TABLE 9. DUST LEVELS MEASURED WITH A GCA SAMPLER IN MILL D.

AREA	GCA	EQUIVALENT VE
Cleaning	0.64	1.23
	0.36	0.70
		0.97 = AVG.
Lintering	0.24	0.47
	0.40	0.77
	0.25	0.48
		0.57 = AVG.
Hulling & Separating	1.01	1.95
	0.90	1.73
	1.64	3.16
	1.36	2.62
	1.39	2.68
	2.05	3.95
		2.68 = AVG.
Baling	0.32	0.62
Outside Mill Near Cyclones	0.08	0.16

All measurements are in units of mg/m^3

TABLE 10. DUST LEVELS MEASURED WITH A GCA SAMPLER IN MILL E.

AREA	GCA	EQUIVALENT VE
Cleaning & Lintering #1	0.23	0.45
	0.20	0.39
	1.06	2.04
	0.19	0.37
	0.29	0.56
	0.70	1.35
		0.86 = AVG.
Lintering #2	0.74	1.43
	0.69	1.33
	0.46	0.89
	0.72	1.39
	0.71	1.37
	0.47	0.91
	0.23	0.45
		1.11 = AVG.
Hulling & Separating	0.65	1.25
	0.68	1.31
	0.81	1.56
	0.72	1.39
	1.18	2.27
	0.54	1.04
		1.47 = AVG.
Baling	0.42	0.81
	0.41	0.79
		0.80 = AVG.

All measurements are in units of mg/m^3

TABLE 11. DUST LEVELS MEASURED WITH A GCA SAMPLER IN MILL F.

AREA	GCA	EQUIVALENT VE
Cleaning	0.16	0.31
	0.23	0.45
		0.38 = AVG.
Lintering	0.03	0.06
	0.35	0.68
	0.53	1.02
	0.45	0.87
		0.66 = AVG.
Hulling & Separating	0.49	0.95
	0.38	0.73
		0.84 = AVG.
Baling	0.14	0.27
	0.15	0.29
		0.28 = AVG.

All measurements are in units of mg/m^3

TABLE 12. DUST LEVELS MEASURED WITH GCA, TSI, AND VERTICAL ELUTRIATOR SAMPLERS IN MILL H.

AREA	GCA	EQUIV. VE	TSI	EQUIV. VE	ACTUAL VE
Cleaning	1.49	2.87	0.91	1.48	
	1.47	2.83	0.81	1.31	
	1.28	2.47	0.20	1.12	
	2.06	3.97	0.78	1.26	2.522
	1.58	3.04	0.51	0.80	
	1.46	2.81	0.41	0.63	
	1.55	2.98	0.98	1.59	
	2.12	4.08	1.04	1.70	
	0.08	1.54 AVG=2.95	0.34	0.51 AVG=1.16	
Lintering	0.85	1.64	0.39	0.60	
	5.01	9.64	0.46	0.71	
	0.90	1.73	0.17	0.22	
	0.99	1.91	0.91	1.48	
	2.46	4.73	3.41	5.71	
	0.84	1.62	0.15	0.19	1.043
	0.66	1.27	0.24	0.34	0.703
	1.47	2.83	0.48	0.75	
	1.42	2.73	0.33	0.49	
	0.08	0.16	0.28	0.41	
	3.79	7.29	0.34	0.51	
	1.43	2.75	0.34	0.51	
	0.08	0.16	0.11	0.12	
	0.08	0.16	0.23	0.32	
	0.08	0.16 AVG=2.59	0.10	0.10 AVG=0.83	
Hulling & Separating	0.37	0.72	0.21	0.29	
	0.33	0.64	0.41	0.63	
	1.29	2.48	0.57	0.90	
	0.17	0.33	0.21	0.29	
	1.06	2.04	0.34	0.51	
	1.48	2.85	0.36	0.54	1.068
	0.33	0.64	0.07	0.05	
	0.39	0.75	0.22	0.31	
	0.50	0.97	0.26	0.38	
	0.01	0.02	0.21	0.29	
	0.26	0.50	0.28	0.41	
	0.35	0.66 AVG=1.05	0.31	0.46 AVG=0.42	
Baling	0.09	0.18	0.01	0.00	
	0.00	0.00	0.03	0.00	
	0.01	0.02	0.02	0.00	
	0.03	0.06 AVG=0.07	0.02	0.00 AVG=0.00	

All measurements are in units of mg/m^3

TABLE 13. DUST LEVELS MEASURED WITH GCA, TSI, AND VERTICAL ELUTRIATOR SAMPLERS IN MILL I

AREA	GCA	EQUIV. VE	TSI	EQUIV. VE	ACTUAL VE
Cleaning	0.53	1.02	0.45	0.70	
	0.21	0.41	0.30	0.44	
	1.40	2.70 AVG=1.38	1.75	2.90 AVG=1.35	
Lintering #1	1.12	2.16	0.52	0.82	
	1.35	2.60	0.52	0.82	
	2.31	4.45	0.78	1.26	
	2.22	4.27	0.81	1.31	3.261
	1.70	3.27	0.45	0.70	
	2.33	4.48	0.83	1.34	
	2.69	5.18	1.32	2.17	
	2.22	4.27	0.79	1.27	
	1.82	3.50	1.02	1.66	
	1.85	3.56	0.89	1.44	
	2.26	4.35	1.57	2.59	
	3.20	6.16 AVG=4.02	0.95	1.54 AVG=1.41	
Lintering #2	0.82	1.58			1.000
	1.28	2.47			
	0.82	1.58			
	0.62	1.20 AVG=1.71			
Lint Beaters	2.19	4.22	0.62	0.98	
	4.11	7.91	2.52	4.20	
	2.78	5.35	1.86	3.08	4.584
	2.64	5.08	1.40	2.30	
	2.57	4.95 AVG=5.50	1.77	2.93 AVG=2.70	
Hulling &	1.10	2.12	0.20	0.27	
Separating	0.09	0.18	0.51	0.80	
	0.92	1.77	0.15	0.19	
	0.29	0.66 AVG=1.18	0.24	0.34 AVG=0.40	
Baling	0.22	0.43	0.09	0.09	
	1.58	3.04	0.45	0.70	
	0.68	1.31	0.61	0.97	0.734
	0.83	1.60	0.68	1.09	
	1.52	2.93 AVG=1.86	1.01	1.64 AVG=0.90	

All measurements are in units of mg/m^3

TABLE 14. DUST LEVELS MEASURED WITH GCA, TSI SAMPLERS AND VERTICAL ELUTRIATOR IN MILL J

Dust Measurements and Calculated Equivalent Vertical Elutriator (VE) Values.

AREA	GCA	EQUIV. VE	TSI	EQUIV. VE	ACTUAL VE
Cleaning	1.90	3.66	0.58	0.92	
	1.56	3.00	0.29	0.43	
	1.50	2.89 AVG=3.18	0.44	0.68 AVG=0.68	
Linter	1.50	2.89	0.41	0.63	
	1.55	2.95	0.39	0.60	
	1.45	2.79 AVG=2.88	0.60	0.95 AVG=0.73	
(a) Linter Beater	2.20	4.23	0.46	0.71	
	2.93	5.64	0.64	1.02	
	2.64	5.08 AVG=4.98	0.61	0.97 AVG=0.90	
(b) Abrasives	0.86	1.66	0.15	0.19	2.035
	1.03	1.98	0.31	0.46	1.215
	1.11	2.14	0.17	0.22	0.885
	1.98	3.81	0.29	0.43	1.38 = AV
	0.82	1.58	0.38	0.58	
	0.95	1.83	0.29	0.43	
	1.07	2.06 AVG=2.15	0.36	0.54 AVG=0.41	
Hulling	1.60	3.08	0.66	1.05	
	1.39	2.68	0.58	0.92	
	3.72	7.16	0.73	1.17	
	2.88	5.54	0.60	0.95	
	4.68	9.00	1.62	2.68	
	6.09	11.71 AVG=6.53	2.06	3.42 AVG=1.70	
Baling	0.43	0.83	0.22	0.31	
	0.39	0.75	0.22	0.31	
	0.43	0.83 AVG=0.80	0.13	0.16	
			0.17	0.22 AVG=0.25	

All measurements are in units of mg/m^3

accurate data. The data from GCA and TSI samples do indicate relative concentrations in each area from each mill.

The high concentrations found in the cleaning rooms of Mills A, B, H, I, J, and K again reflect the input of stripper harvested cotton. Although Mill C had high concentrations in its cleaning room, the "picker harvested" mills had lower concentrations of dust in the cleaning room which often carried over into the linter rooms.

One process which is extremely dusty is that of lint beating. Values from Mill I would seem to substantiate this idea. Since most lint beaters are located in close proximity to the linter area, this process would seem to be a major contributor to dust in the linter area. With the exceptions of Mills B, H, and I, the hulling and separating rooms consistently seem to have high dust concentrations relative to the rest of the mill. This would seem to support the inference that the delintering process creates more dust in the cottonseed which is released during the hulling and separating process.

The difference between mills processing seed harvested by pickers and mills processing stripper harvested seed indicate that different or more radical controls may have to be utilized by the "stripper" mills. These differences alos indicate that no one design or control is best for the entire industry. Each situation must be taken into consideration for controls to be effective and appropriate.

As a result of the results from dust levels in the cottonseed samples as well as the GCA and TSI readings and reports from industry engineers, mills in this study were ranked for participation in the detailed study using the vertical elutriator to document the level of dust control. The best, or, first choice is Mill K, Lamesa Cotton Oil. Although this mill did not have the lowest dust levels from seed and no GCA or TSI samples were taken, this mill has been completely rebuilt and incorporates new and practical dust control technology. The next choice is Mill L, Plainview. This mill is being rebuilt by W.C. Cantrell Company and should be operating in October or November, 1979. Some innovative approaches to dust control as well as an innovative building design (windowless, with circular vents on a flat roof) should minimize dust concentrations at this mill.

The third ranked mill, Traders Oil Mill, Fort Worth, is owned and operated

by Buckeye Cellulose, a division of Proctor and Gamble. Although it was not possible to visit or sample this mill, it has a number of ventilation systems to remove dust from the source and uses a central vacuum for cleanup purposes. Therefore from the standpoint of lowering dust levels in existing mills it would be desirable to have this mill participate in further studies.

The fourth ranked mill is Mill B, H, and I at Sweetwater. This was the cleanest mill processing cottonseed from stripped cotton. I also had the cleanest baling room samples. The fifth mill, Producers in Fresno, California - Mill F, is a picker cotton mill. This mill has the best maintenance. The remaining mills ranked in order are:

(6) Mill J - Anderson-Clayton, Lubbock, Texas. This mill had fairly high dust levels, but has excellent abrasive linters.

(7) Mill E - Ranchers, Fresno, California. This is the only mill using a scrubber for air pollution abatement. It also had fairly low dust levels with methods used in this study.

(8) Mill I - Plains Cooperative, Lubbock, Texas. The small linter room in this mill uses Murray Carver linters. It also has an outstanding abatement system design in baling room.

(9) Mill A - Anderson-Clayton, Abilene, Texas. Although this is a small mill and had fairly high dust levels, its hulling and separating operation is isolated in a separate room. This mill is considering placing a high-volume seed cleaner in line following their abrasive linters.

(10) Mill D - Anderson-Clayton, Phoenix, Arizona. This mill uses bag filters systems and abrasive linters. This study showed fairly low levels of dust in cottonseed samples collected, but this was mainly due to processing of picker harvested cottonseed.

(11) Mill D - Boswell, Corcoran, California. Again a picker cotton mill, this mill is not recommended for further study because it is small and uses unusual separating equipment resulting in an extremely high dust concentration in the hulling and separating process.

IV. ENGINEERING DUST CONTROLS

The primary objective of this project was to survey cottonseed oil mills for effective dust controls. Although no mill visited has been completely successful in controlling dust in all areas, certain controls were observed that seem to be effective in certain areas. The controls discussed below, while not being cure-alls, could possible make a significant impact on lowering respirable dust concentrations when used collectively.

Seed Cleaning

This operation is traditionally the dirtiest of all cottonseed oil mill processes. Controls in this area will be helpful not only to this process but may also be critical to the dust concentrations levels for the rest of the oil mill.

One much discussed control is the use of hoods or shrouds on the cleaning machines. Because of the operation and maintenance needs of this equipment, total enclosure is nearly impossible. Some mills have installed ventilation hoods at the ends of the cleaners to remove dust generated by seed falling from tray to tray. However, these hoods seemed to have little effect on dust generated from the middle of the trays and out the sides of the equipment.

Of the mills visited, two have incorporated equipment in seed cleaning that have potential in reducing dust concentrations. Mill H has installed three Centron cleaners as precleaners to their Bauer cleaners. Figure 13 shows one of these machines in operation. These precleaners removed trash, lint, sticks, and rocks but more importantly they removed a good deal of sand and dirt as shown in Figure 14. Also of importance, these machines could be fitted with ventilation hoods, if necessary, in such a way as to be of minimum hinderance in maintenance and operation. Mill J incorporated a shaker similar to the Centron machines of Mill H. Dirty seed was augered from the seed tank directly to the shaker which was fitted with a canvas ventilation hood. This hood was part of a negative pressure ventilation system serving each cleaning machine. The dust collected by this system was conveyed to two long-cone cyclones which did an excellent job of dust collection.

Mill K has also incorporated precleaners in its operation but they are of a different configuration. This system incorporates two Link-Belt design,

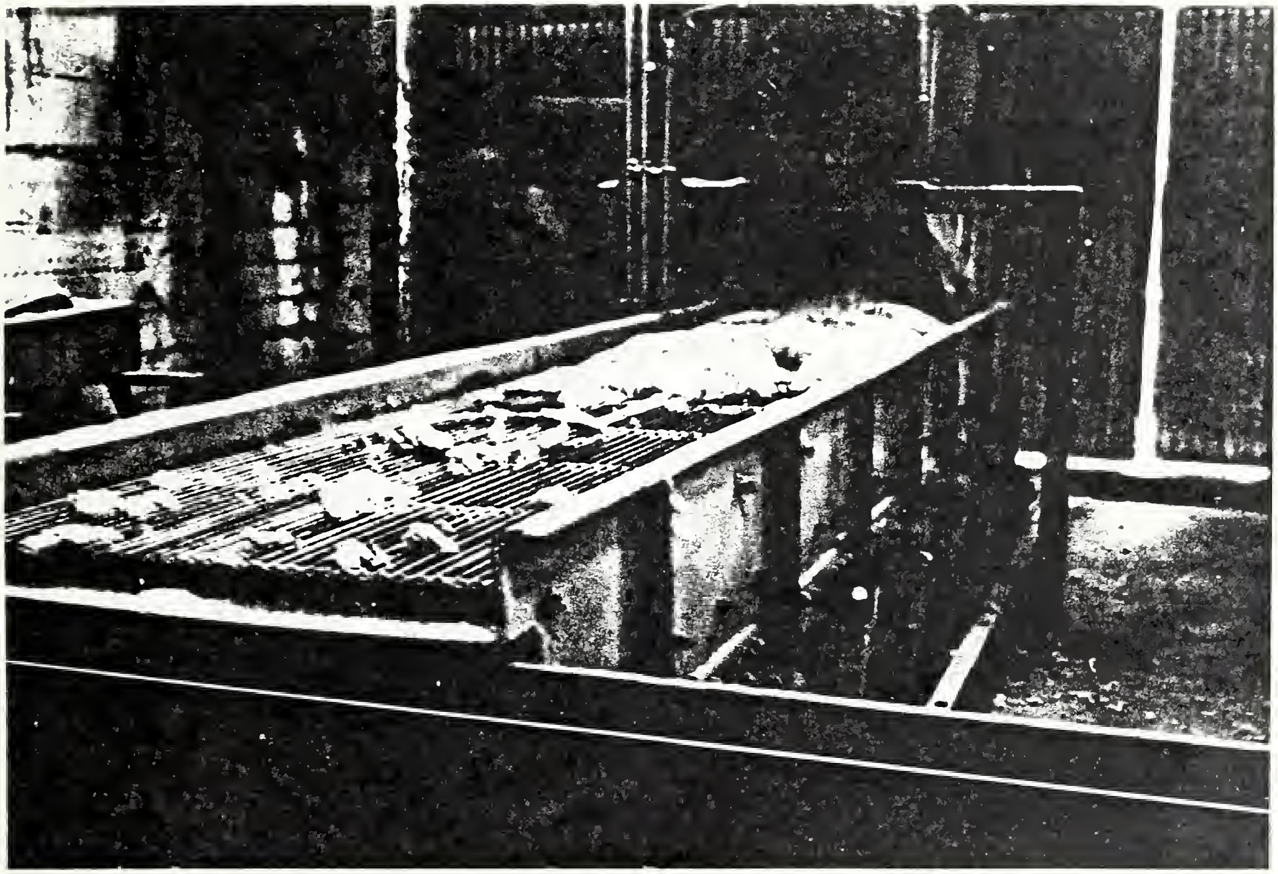


FIGURE 13. View of a Centron cleaner being used as a seed precleaner at Mill H.

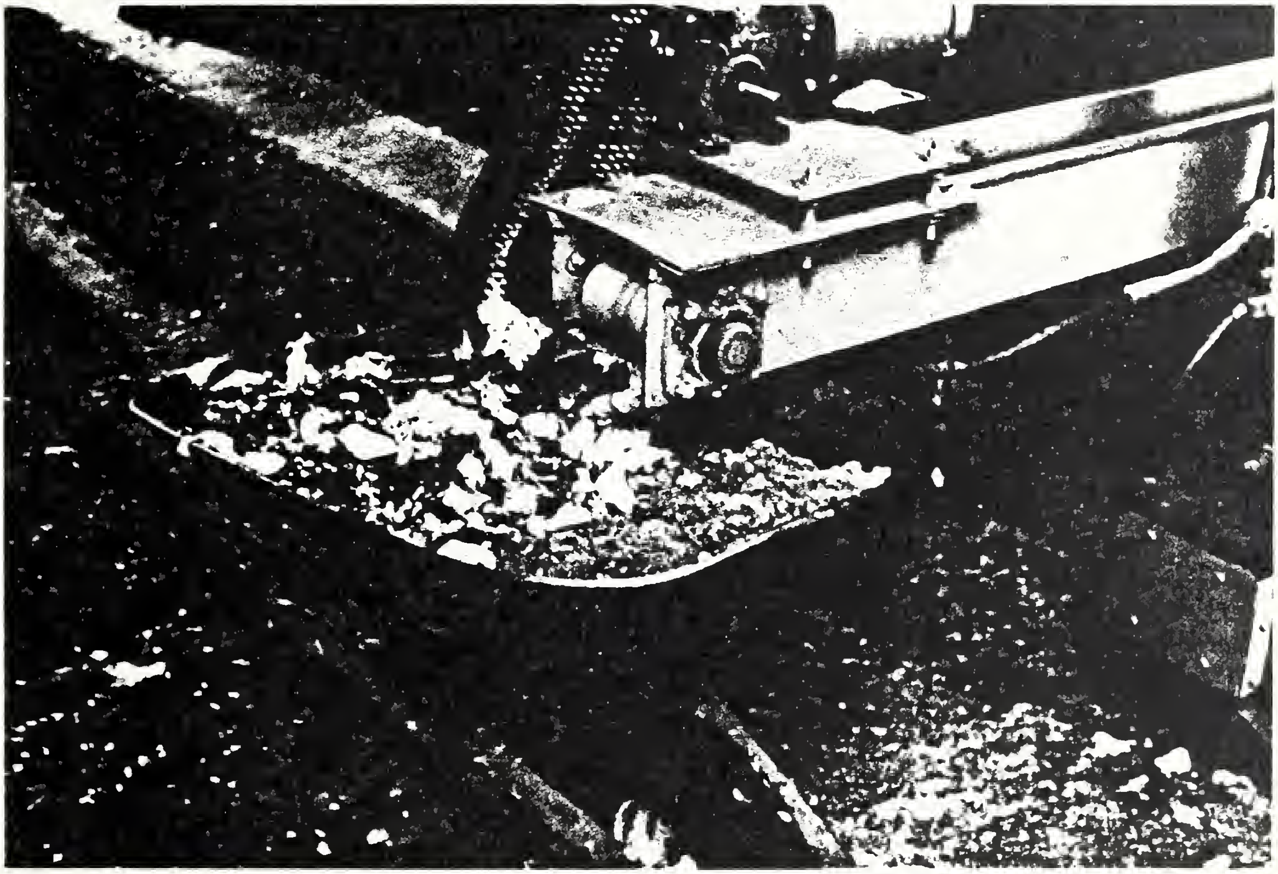


FIGURE 14. Typical material separated from cottonseed by a Centron Cleaner.

enclosed boll reels in series. The first reel consists of large mesh sheet metal and removes large trash and stones. The second reel is made of much finer mesh and removes small trash and sand. These precleaners are located in a separate building from the cleaning room and all material collected is removed to a collection point outside the boll reel building.

Auger conveyors with perforated bottoms are being used by some oil mills to remove sand during conveying of seed to the cleaning process. One such system at a cotton gin was arranged such that a second auger, positioned directly under the perforations and operating in the opposite direction, picked up all separated sand and trash and conveyed it to a collection point as part of the dust control system.

More consideration should be given to some type of precleaning or trash separation such as the above. Any dust removal that can be accomplished by controlled systems such as those mentioned above should decrease dust concentrations in every other area of the mill.

Linters

Because of the design of present saw-type linters, large quantities of process stream air enter the linter area. Often this process air originates from other areas of the mill and from ambient air. Thus, the linter area is often subject to high dust concentrations because of dust generated in other areas. To alleviate this problem completely would require the separation of the linter area from the rest of the mill. This could easily be accomplished in future mill construction, but for present mills partitioning the linter area from the rest of the mill would be too costly if not physically impossible. Thus to prevent dust generated in other areas from migrating to the linter area, will require controls in those other areas. In addition to this migrating dust, the saw linters themselves can generate dust. Many mills have tried, with varying degrees of success, to enclose their linters using canvas, plexiglass, or wood covers. The Carver Company has recently incorporated metal covers above the seed roll and linter saw of their linters which are hinged (Figure 15 and Appendix B, letter from Murray-Carver, Inc.). These enclosures seem to have great promise. Mill I is utilizing these linters in one segment of its operation with good success. Mills K and L will both use these linters in their redesigned mills.

Mills A, C, and J are using abrasive-type linters exclusively for their

FIGURE 15. View of enclosed Carver linters installed in Mill I.

last cut on the seed. When properly closed and maintained, these linters are very clean in respect to the working environment. However, because there can be a fear of fire from these machines, they are often left open while operating to be easily monitored. When this occurs, tremendous amounts of dust can be generated. Also, as mentioned in section III of this report, the dust content in seed following the abrasive process is extremely high. This results in high dust concentrations in the hulling and separating areas of the mill.

Ventilation hoods for saw-type linters seem to be unfeasible since saws must be removed and sharpened for each linter on a daily basis. Effective hoods would greatly hamper this maintenance and seem to be unnecessary in the light of the Carver enclosures.

Hulling and Separating

Hoods for ventilation seem to be physically feasible controls in this area of the mill. Mill F had installed a ventilation hood over its safety shaker which seemed to do an admirable job in dust control and which is shown in Figure 16. Hoods such as this could be used on many of the shaker-type machines in this area. However, the cost of such systems could prove to be prohibitive.

The Chandler Company has developed an enclosure for the back of its huller. Much dust is generated at the back of present hullers, and an enclosure could be a great help in dust control. Although none of the new Chandler hullers were being used during this study, they will be installed at the Mill L renovation.

Baling

Several mills have designed aspiration systems for their bale presses. Figure 17 illustrates typical suction systems that are placed above the tramper or above the exit of the linter chute. Mill H had the cleanest room, with negligible dust concentrations in the working environment (~ 0.02 mg/m^3), and utilized an aspiration system. In comparison, other rooms without any controls were extremely dirty.

Maintenance and Managerial Practices

Pneumatic conveying systems are used extensively in oil mills. If ventilation hoods and other similar controls are used more in the future this use of pneumatics will increase. During this study poor maintenance of positive

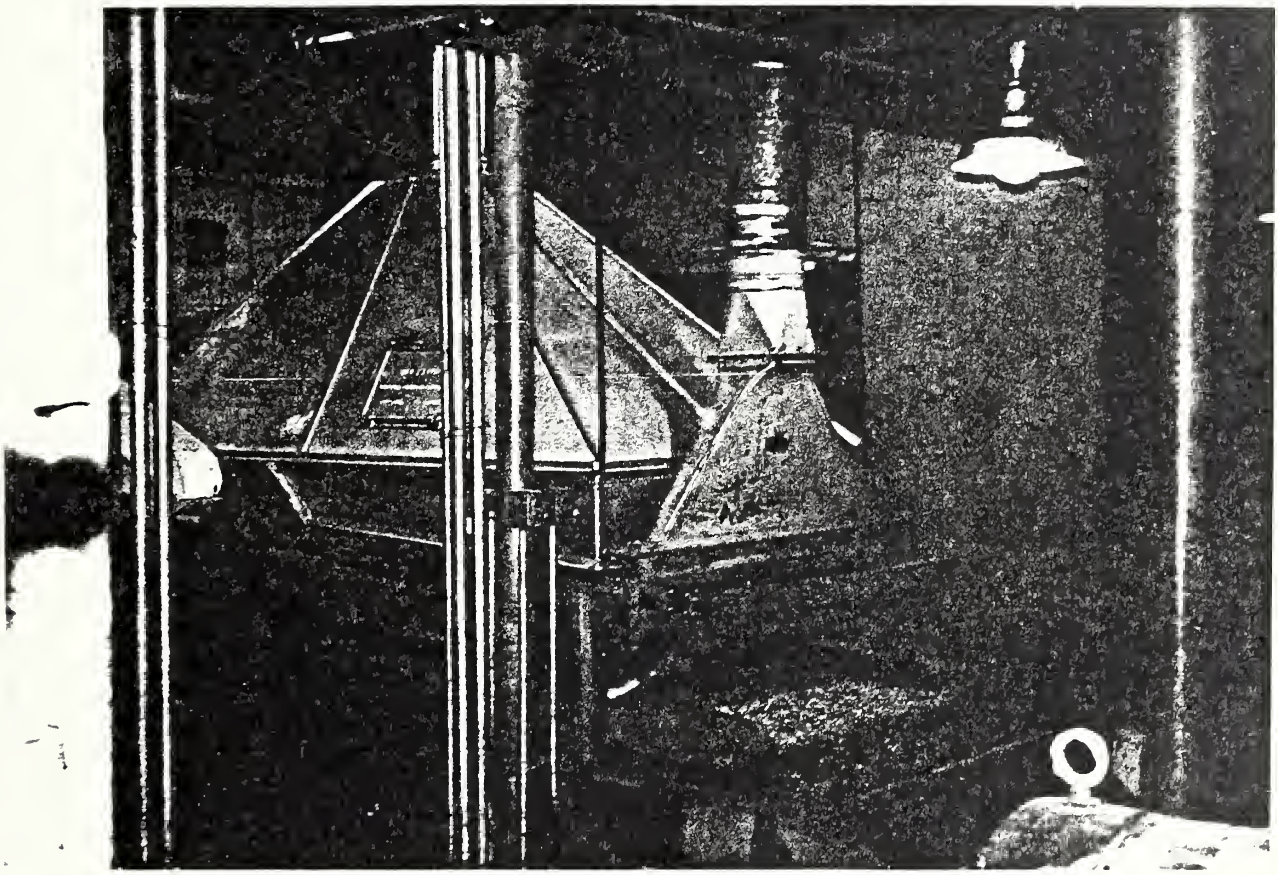


FIGURE 16. Installation of a ventilation hood above safety shaker at Mill F.

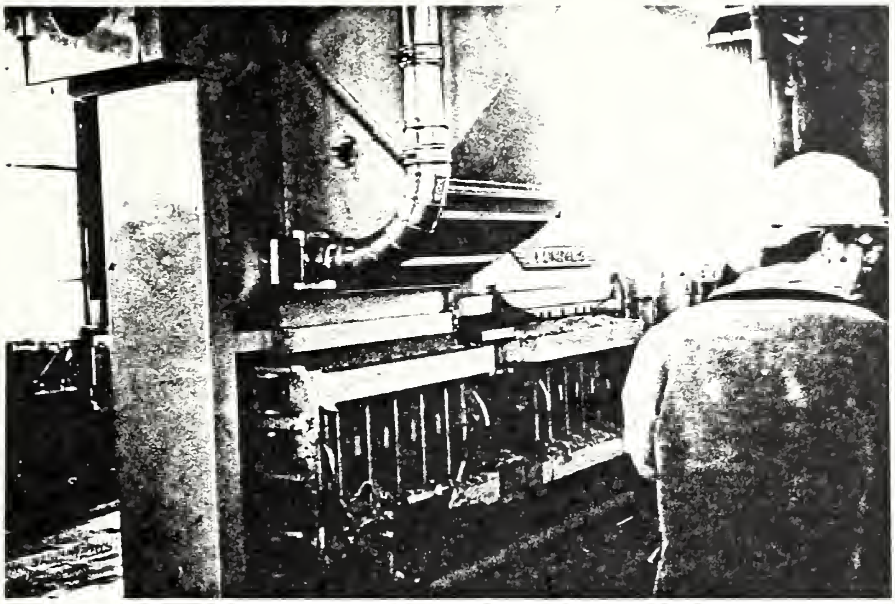


FIGURE 17a. Ventilation system on a Lummus bale press.

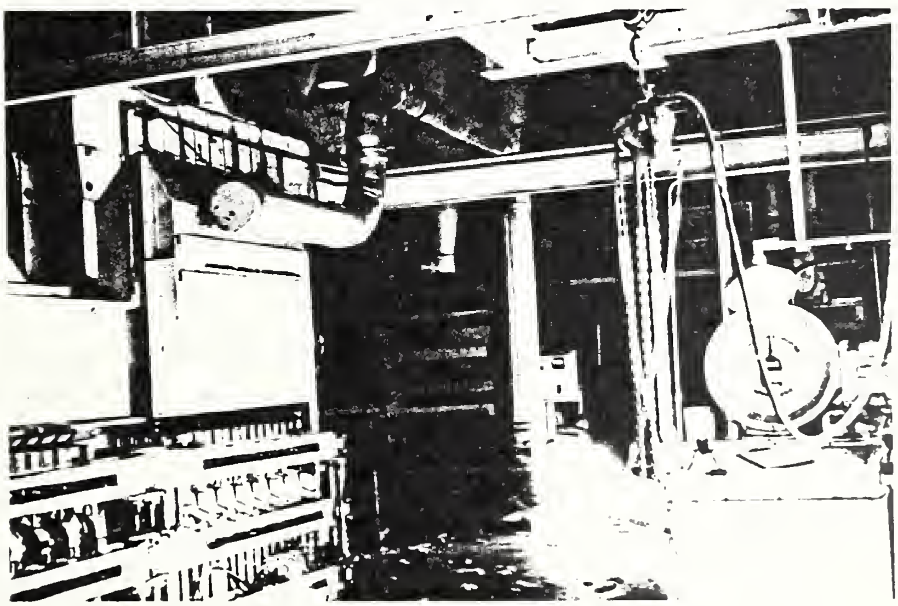


FIGURE 17b. Aspiration on bale press at lint chute where cotton enters press.

pressure pneumatic systems was observed to be as large a dust source in many cases as was the actual processing machinery itself. Unless proper maintenance and managerial practices are followed, even the best dust control system will be rendered useless. Constant repair of poor duct joints and holes in ducting is a must if positive conveying systems are to be used.

In several cases positive pressure systems have been displaced by negative pressure systems, especially inside mill buildings. Thus, maintenance becomes less crucial as holes in ducting cannot become dust sources under such systems.

Re-entrainment of dust from ambient air can be a problem when poor planning allows exits from dust collectors, such as cyclones, to be placed near windows and doors of buildings. Blowdowns with compressed air facilitate mill cleanup but also entrain dust and lint into the work environment from ledges and machine tops. Vacuum systems would seem to be a much more appropriate approach to cleanup.

Recent and ongoing renovations of Mills K and L have taken such problems into consideration. These two mills have incorporated the exclusive use of negative pneumatic conveying systems in transferring material out of buildings and return material into buildings only by auger conveyors. New enclosed linter and huller machines are being installed and dust collection systems are being situated such that the prevailing winds carry any uncollected dust away from the mill to minimize re-entrainment in the working environment. Any future studies of oil mill dust control should study these two mills,as much of the latest innovations and "common sense" designs are being incorporated in both.

A paper presented at the Oil Mill Operators Short Course, by project member Stan Clark describing dust sources and suggestions for control,can be found in Appendix C of this report.

REFERENCES

1. Hersh, S.P., R.E. Fornes, S. Batra, M. Anand, and R.H. Johnson. 1979. Characteristics of lard room dust measured by light scattering and short-termed samplers. Proceedings of 1979 Beltwide Cotton Production Conference. Phoenix, Arizona.

2. Matlock, S.W., L.R. Wiederhold, Jr., and C.B. Parnell, Jr. 1976. Particle sizing of dust found in cottonseed oil mill. Trans. ASAE 19(5): 970-976.

3. Parnell, C.B., Jr. 1979. Cotton dust standard -- cottonseed oil mills. Proceedings 1979 Beltwide Cotton Production Conference. Phoenix, Arizona.

4. Occupational Safety and Health Administration. 1978. Occupational exposure to cotton dust -- final mandatory occupational safety and health standards. Fed. Regis. 23(122): 27350-27463.

5. Parnell, C.B., Jr. and S.W. Matlock. 1977. Particle size distributions of dust from the working environment of cottonseed oil mills. Proceedings of the 1977 Beltwide Cotton Production Conference. Atlanta, Georgia.

APPENDIX A

DISCUSSION OF DUST CONCENTRATIONS IN COTTONSEED

The graphs presented in this appendix illustrate the impact of certain oil mill processes on dust levels in cottonseed. Each graph plots the mass concentration of dust in cottonseed samples versus the particle size of the dust. This plotting results in a Mass Concentration Particle Size Distribution (MCPSD) for each part of a mill that is sampled.

The first set of graphs illustrates results obtained for seed samples taken at Mill A. Comparing the results in seed at P_2 to that of P_0 shows the amount of dust removed by the cleaning process. A slight increase in dust occurs after the first cut delinters, but a dramatic increase occurs after the second cut. This increase is due to the use of abrasive delinters. The effects of this dust increase is shown by the large dust concentrations found in the hulling area sampling with the GCA and TSI air samplers. This situation occurs in every mill that uses abrasive delinters in which we sampled.

Mill B has a high dust concentration in entering seed due to its processing of stripped cotton. However, its cleaners do a reasonable job of reducing this concentration and it remains relatively small throughout the mill.

Mill C processes picked cotton, which is very clean entering the mill. Some dust is generated in the lower size ranges after the cleaners, but, again with the use of abrasive delinters, a large increase occurs following the second cut delinters.

Mill D, processing picked cotton, has relatively small dust concentrations ($\sim$ .05 mg/g @3 μm) throughout. Mills E and F, also processing picked cotton, follow much the same patterns.

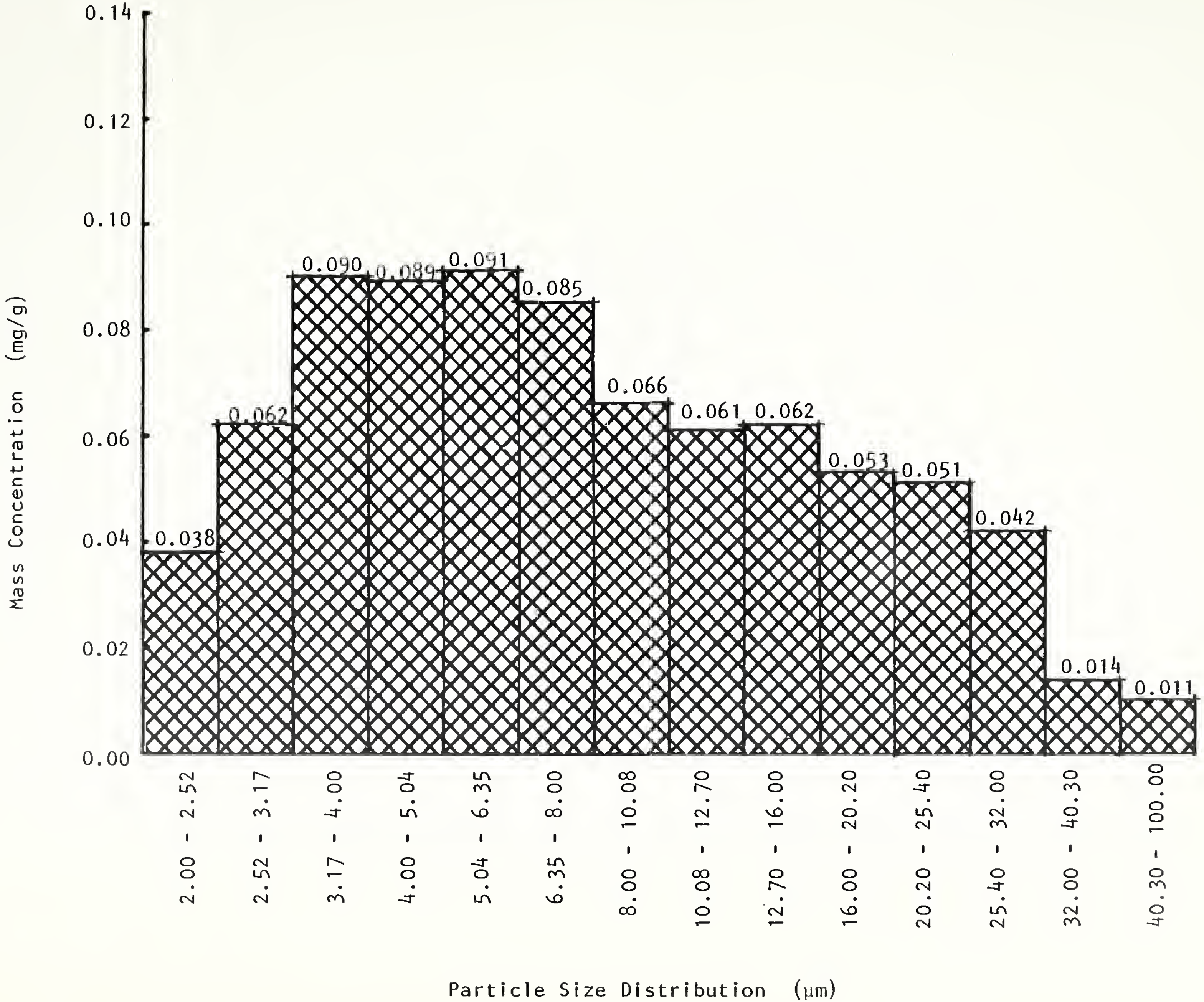
Mills G and H are the same mill, handling stripped cotton, sampled on different days. The differences in its dust concentrations can be explained by many factors including atmospheric conditions. But, even with some differences, the same basic trend in dust content and size holds under both sampling conditions. Mill I also handled stripped cotton and shows the same type of results in dust content in its seed.

Mill J handled stripped cotton but also utilized abrasive delinters on its second cut which is reflected in its increase in dust content at station P_4.

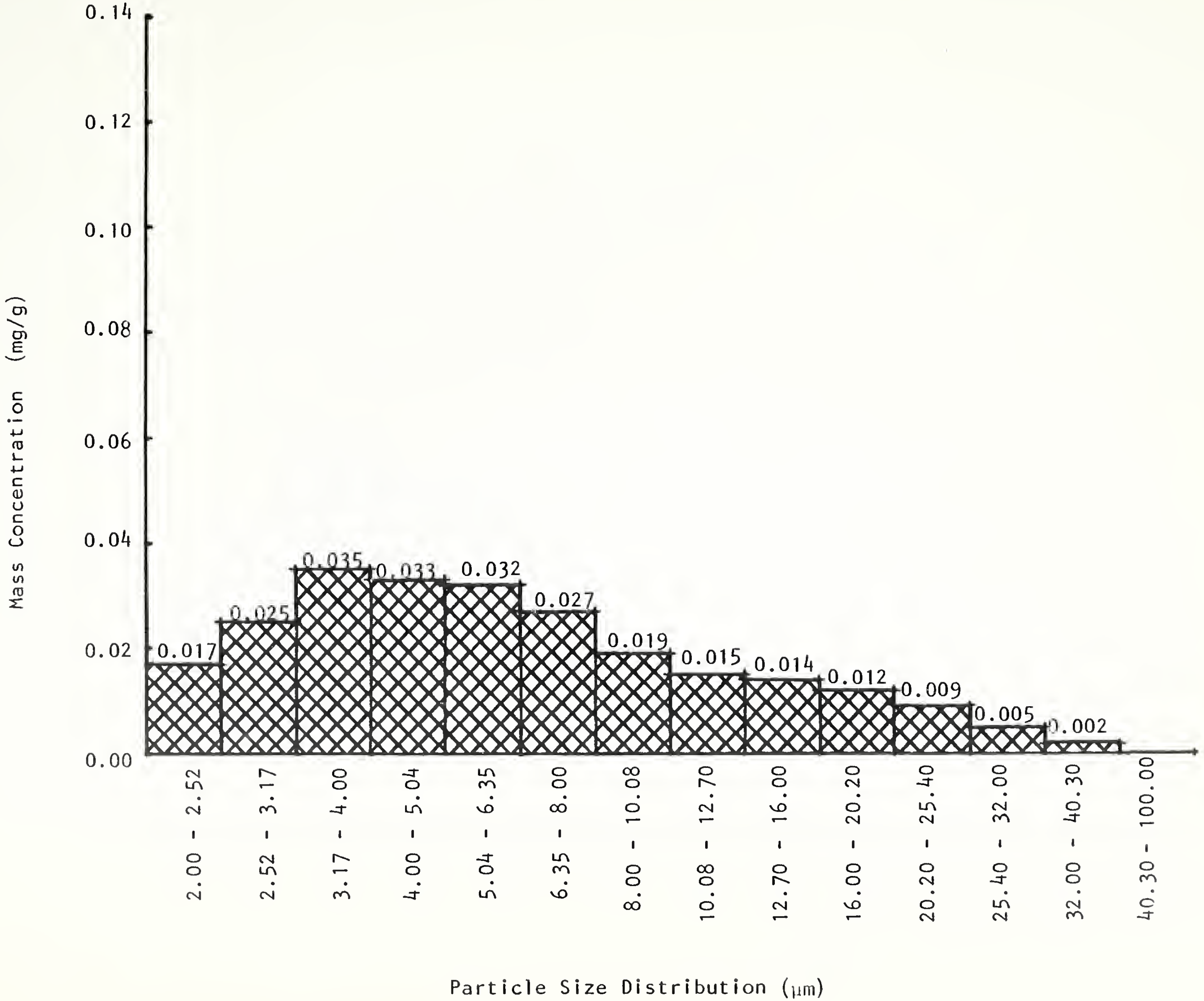
Mill K processed stripped cotton and used a precleaner between P_0 and P_1. However, this precleaner can be seen to have little effect in lowering seed dust levels.

In studying these graphs the reader should realize that from mill to mill the vertical axis of each set of graphs may change. Thus, at a glance many mills seem to have very high dust levels when after studying the actual numbers this may not be the case.

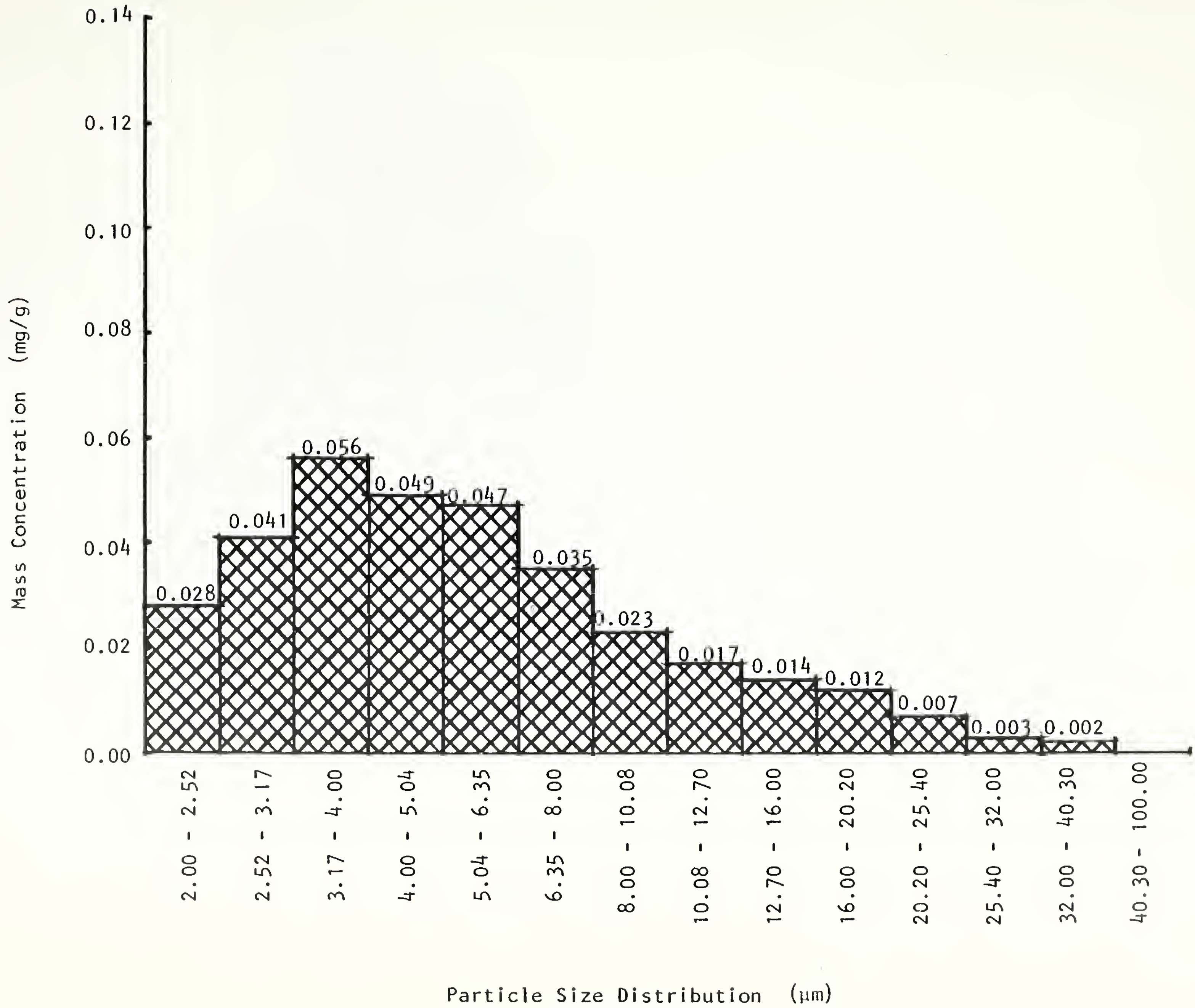
Mass Concentration - Particle Size Distribution
Mill A
P_0

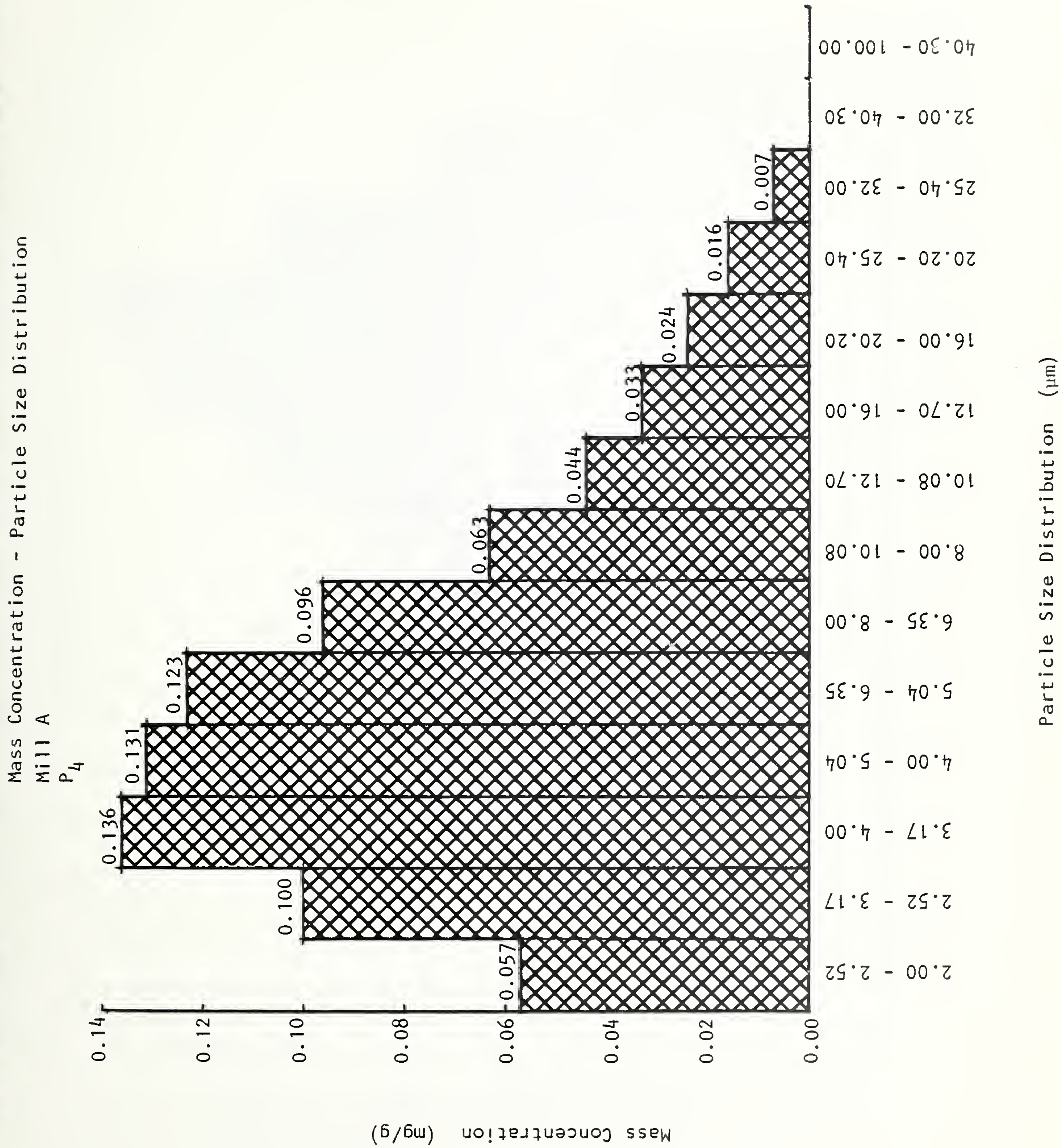


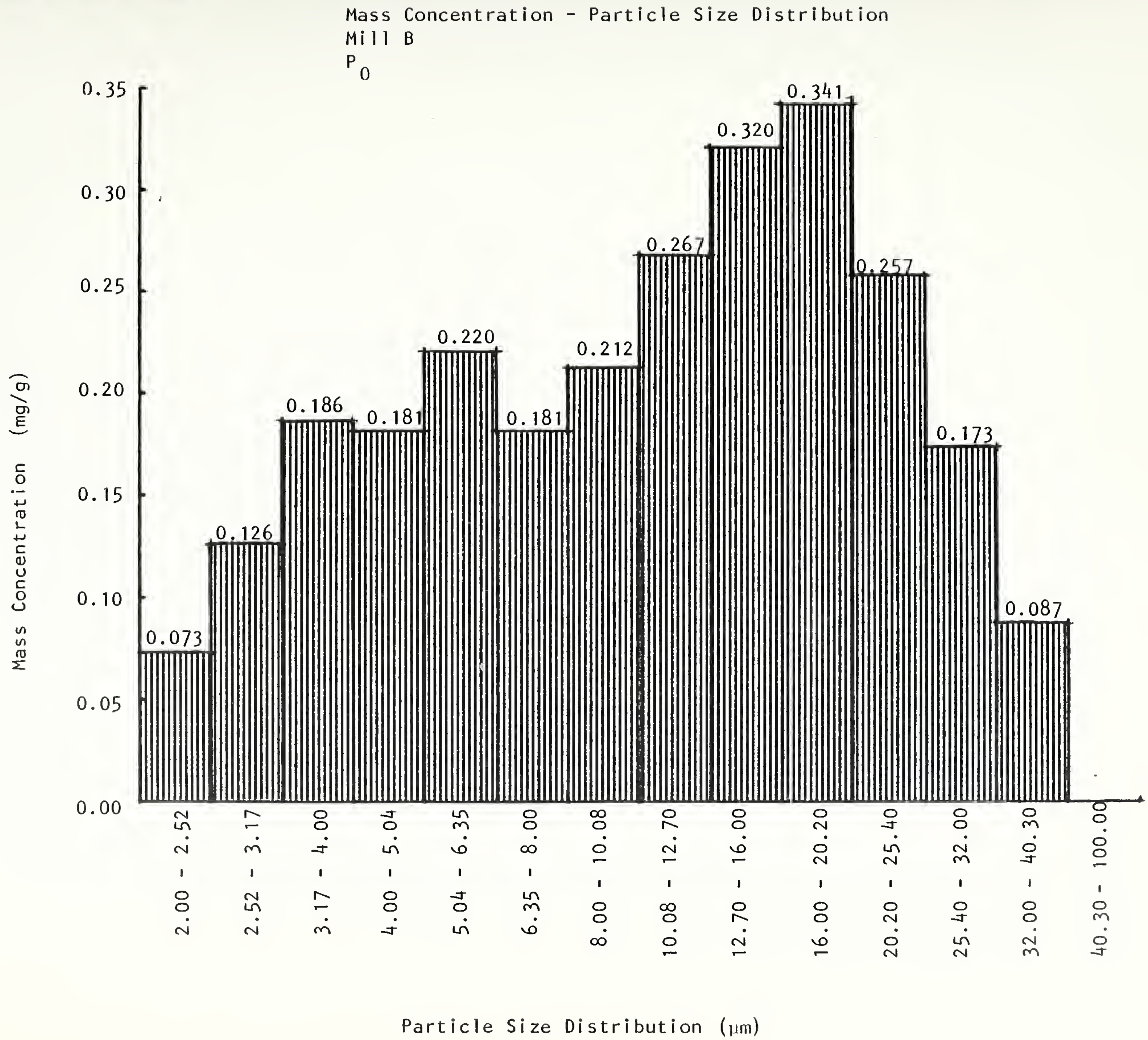
Mass Concentration - Particle Size Distribution
Mill A
P_2



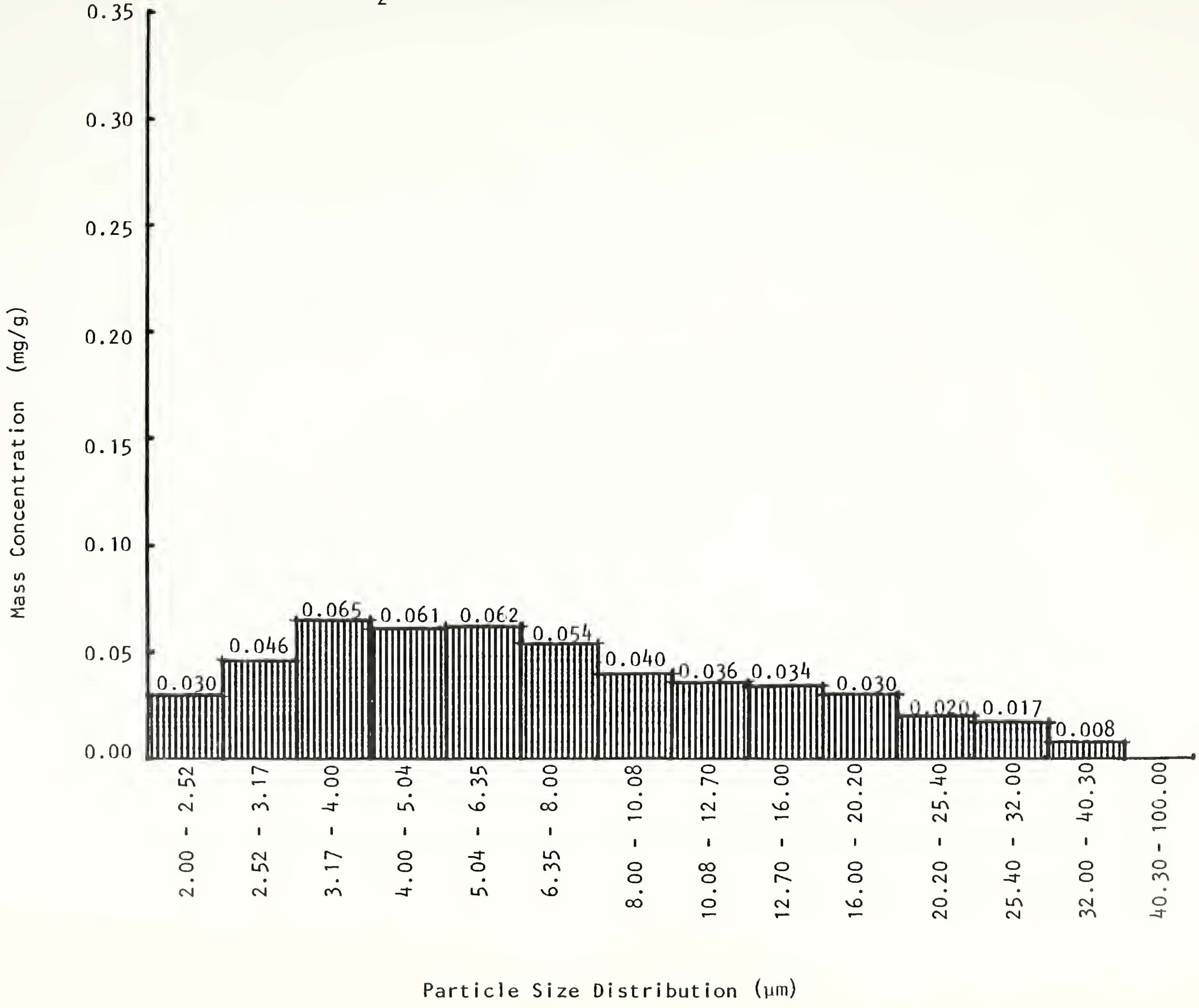
Mass Concentration - Particle Size Distribution
Mill A
P_3



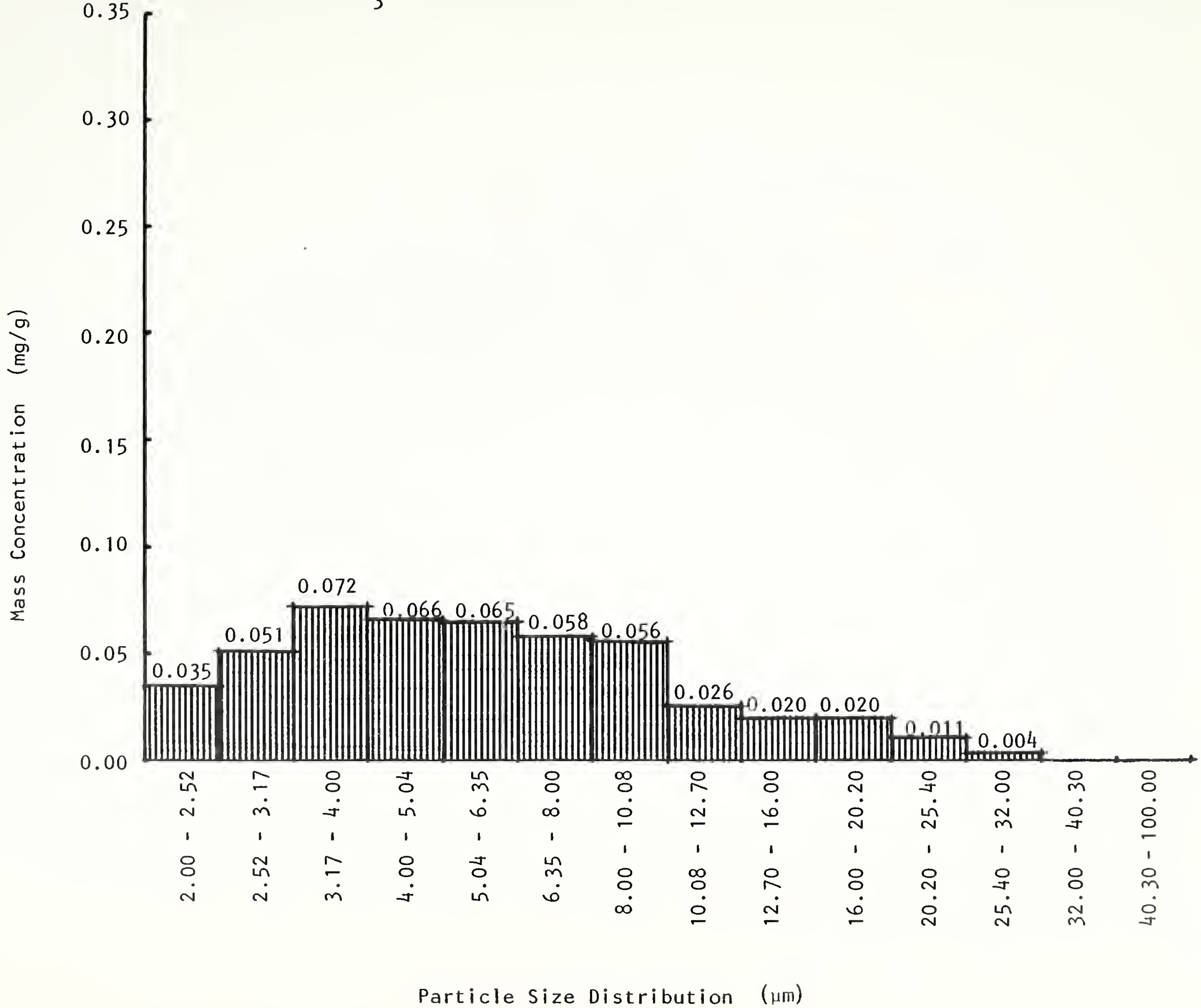

Mass Concentration - Particle Size Distribution
Mill A
P4
Mass Concentration (mg/g)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
Particle Size Distribution (µm)
2.00 - 2.52
2.52 - 3.17
3.17 - 4.00
4.00 - 5.04
5.04 - 6.35
6.35 - 8.00
8.00 - 10.08
10.08 - 12.70
12.70 - 16.00
16.00 - 20.20
20.20 - 25.40
25.40 - 32.00
32.00 - 40.30
40.30 - 100.00
0.057
0.100
0.136
0.131
0.123
0.096
0.063
0.044
0.033
0.024
0.016
0.007


Mass Concentration - Particle Size Distribution
Mill B
P_0
Mass Concentration (mg/g)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.073
0.126
0.186
0.181
0.220
0.181
0.212
0.267
0.320
0.341
0.257
0.173
0.087
2.00 - 2.52
2.52 - 3.17
3.17 - 4.00
4.00 - 5.04
5.04 - 6.35
6.35 - 8.00
8.00 - 10.08
10.08 - 12.70
12.70 - 16.00
16.00 - 20.20
20.20 - 25.40
25.40 - 32.00
32.00 - 40.30
40.30 - 100.00
Particle Size Distribution (μm)

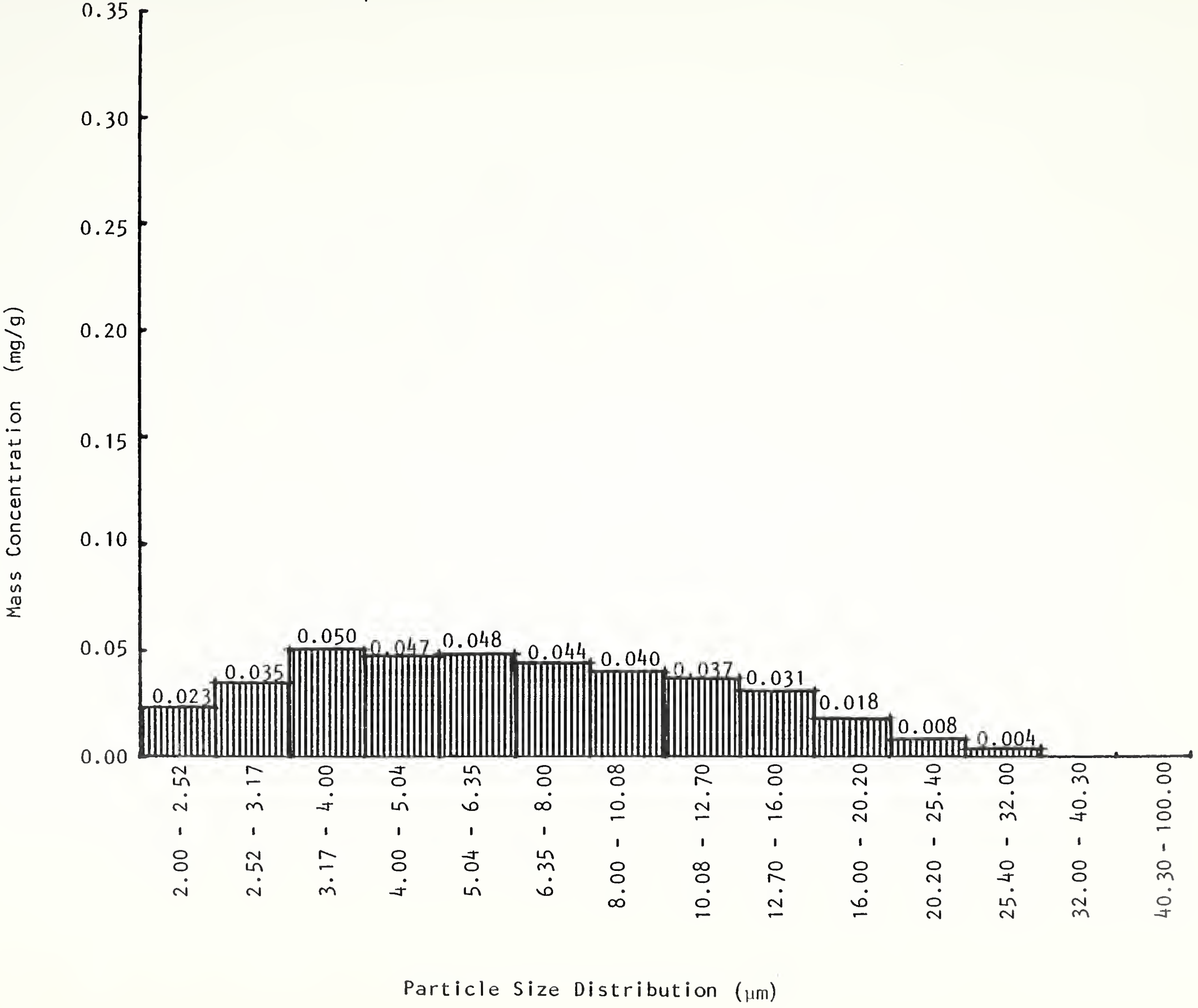
Mass Concentration - Particle Size Distribution
Mill B
P_2



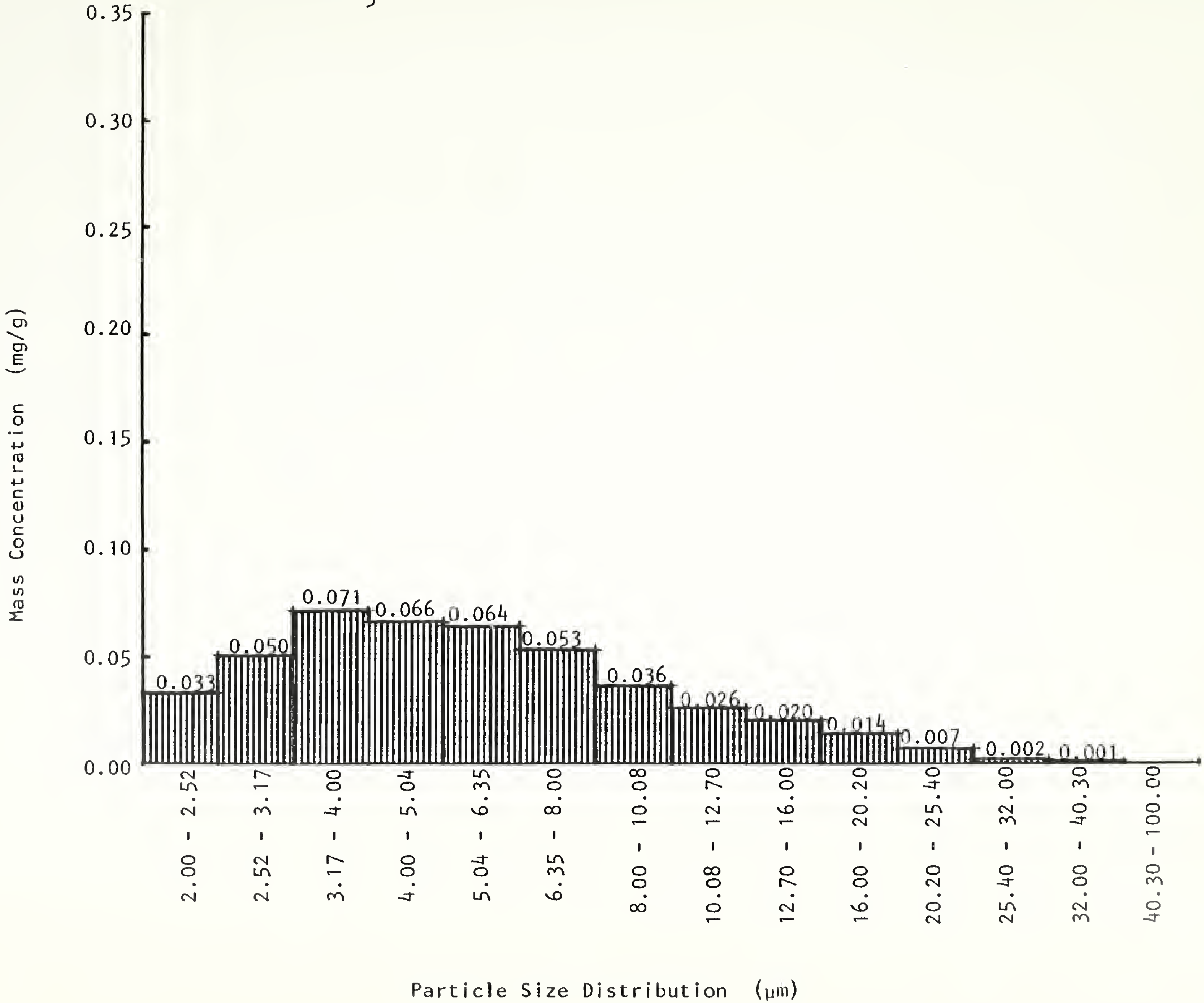
Mass Concentration - Particle Size Distribution
Mill B
P_3



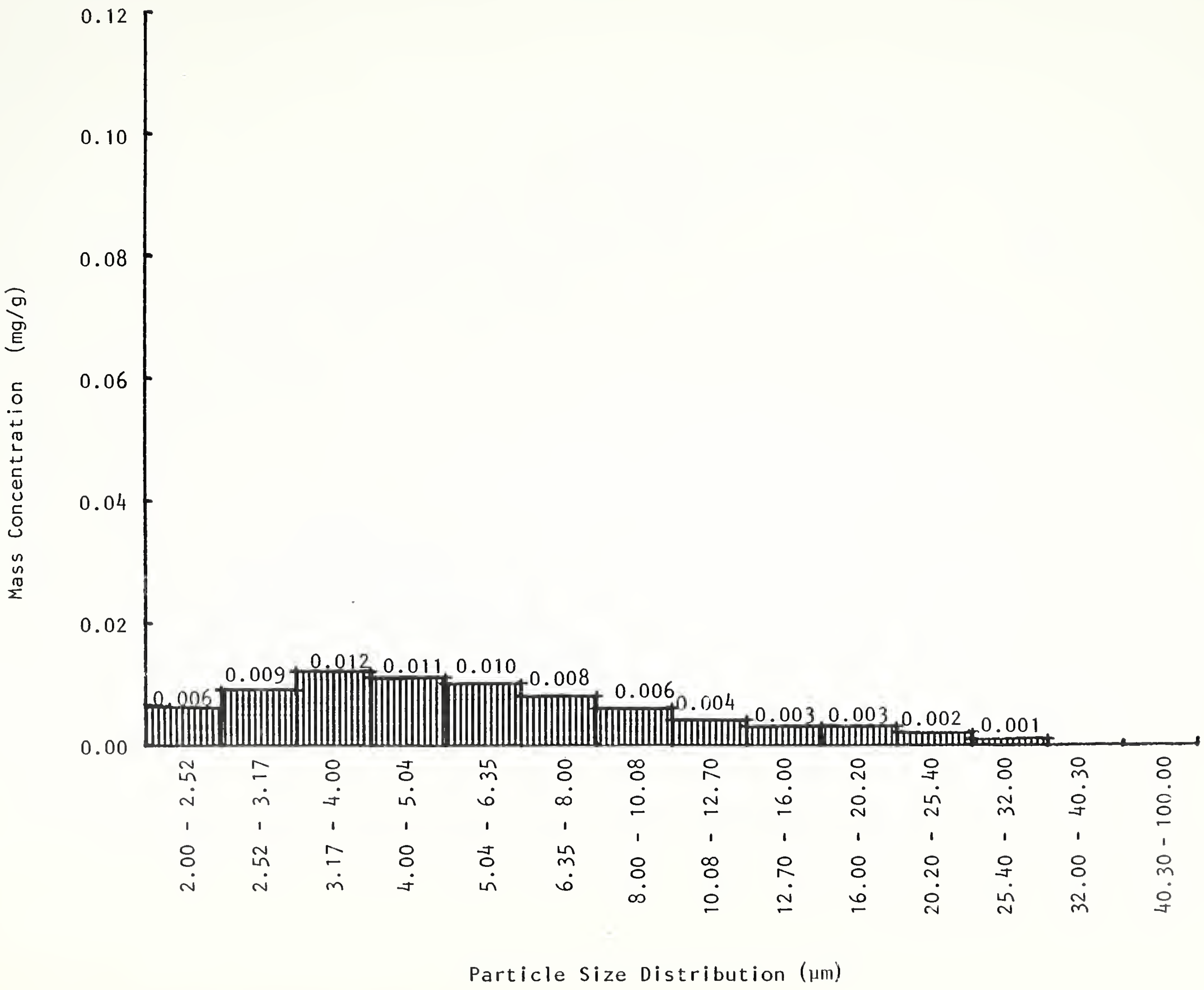
Mass Concentration - Particle Size Distribution
Mill B
P_4



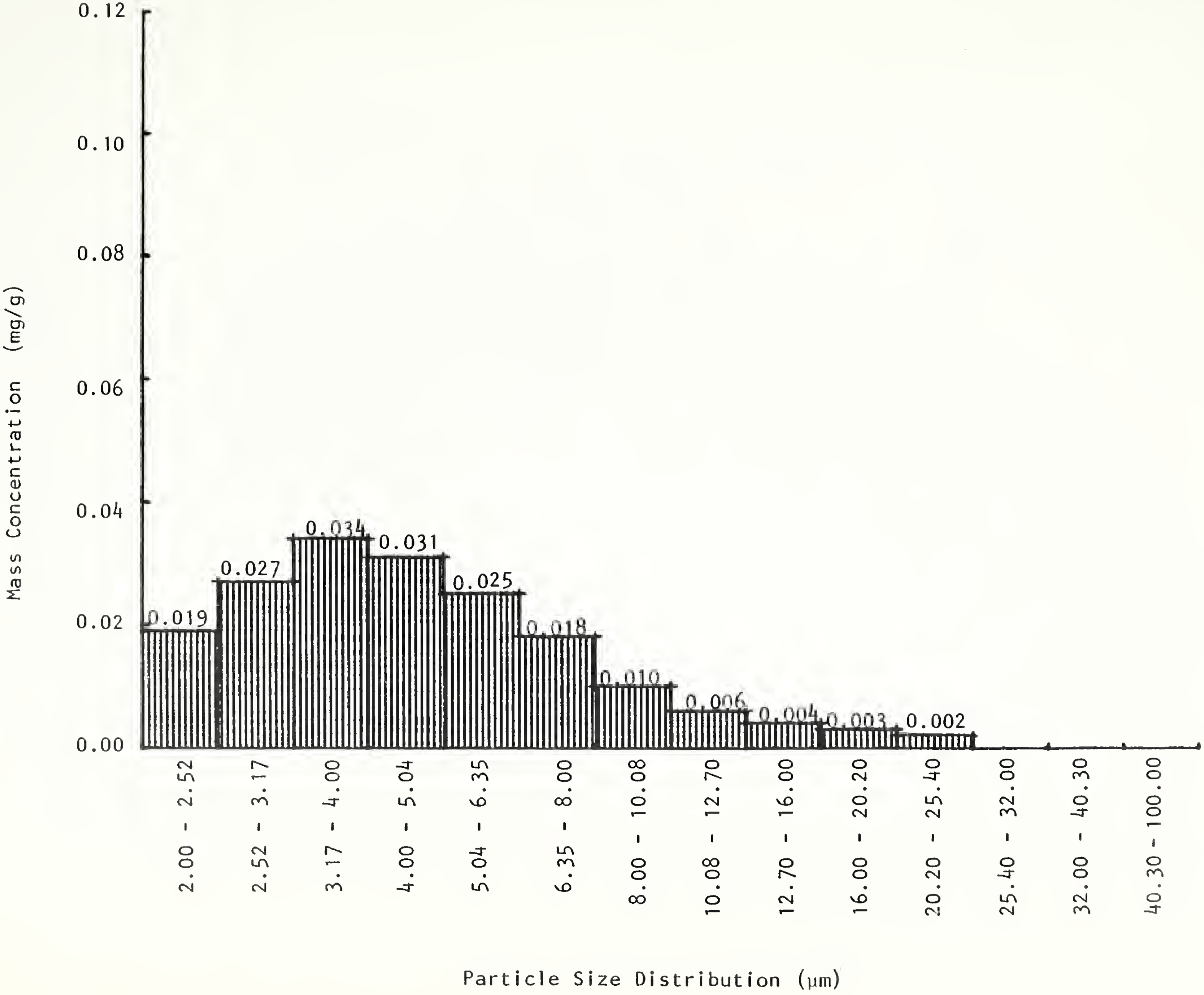
Mass Concentration - Particle Size Distribution
Mill B
P_5



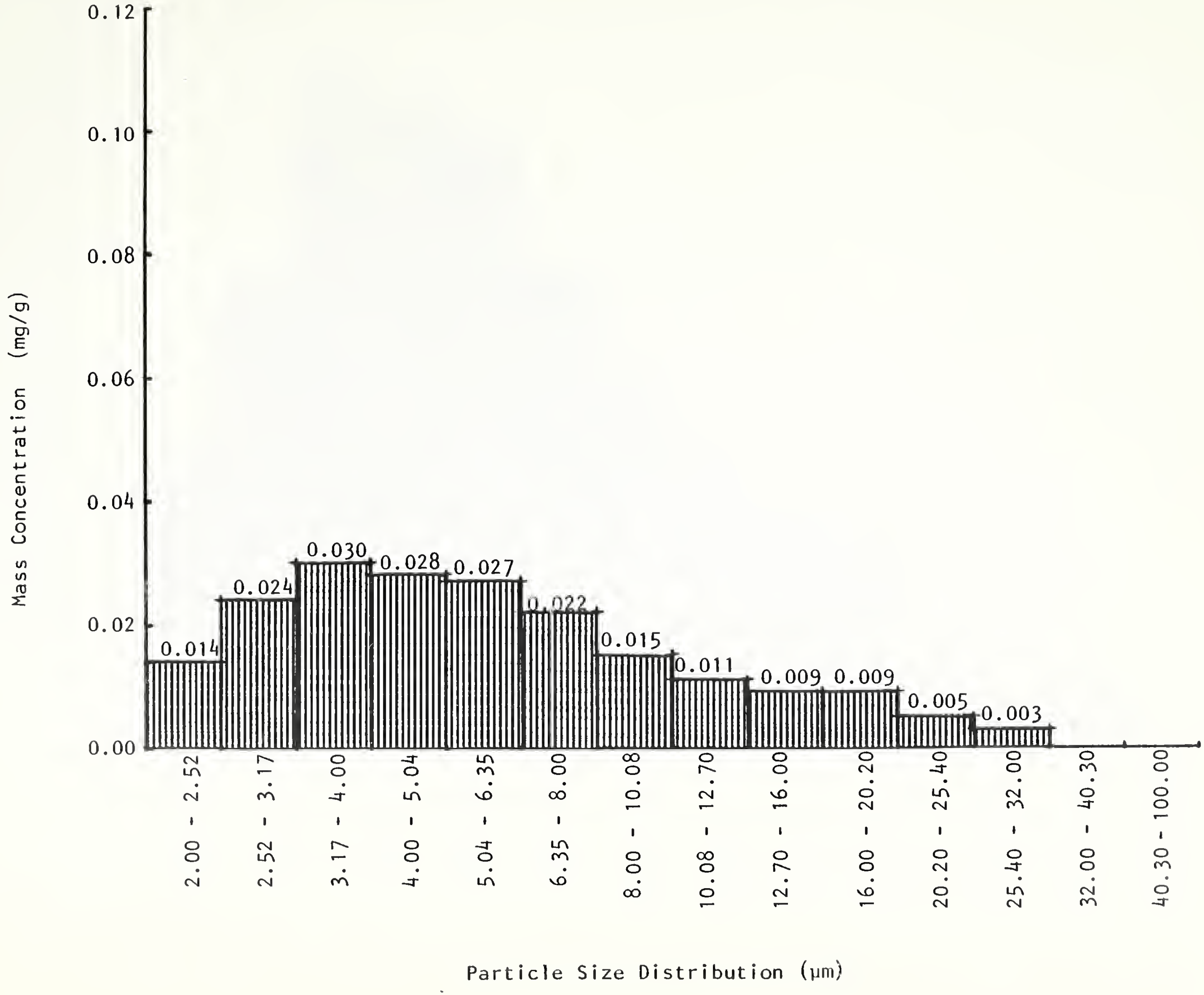
Mass Concentration - Particle Size Distribution
Mill C
P_0



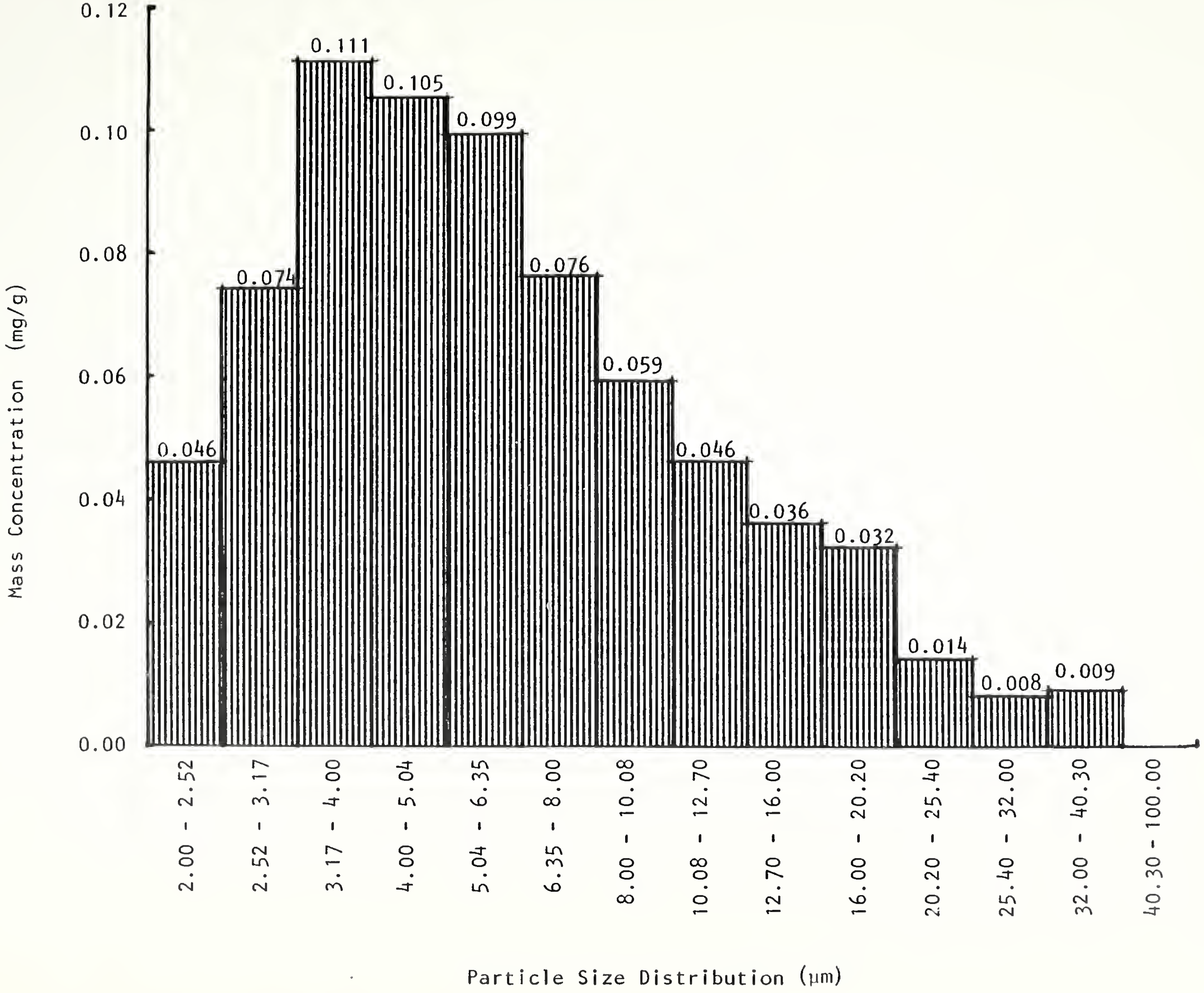
Mass Concentration - Particle Size Distribution
Mill C
P_2



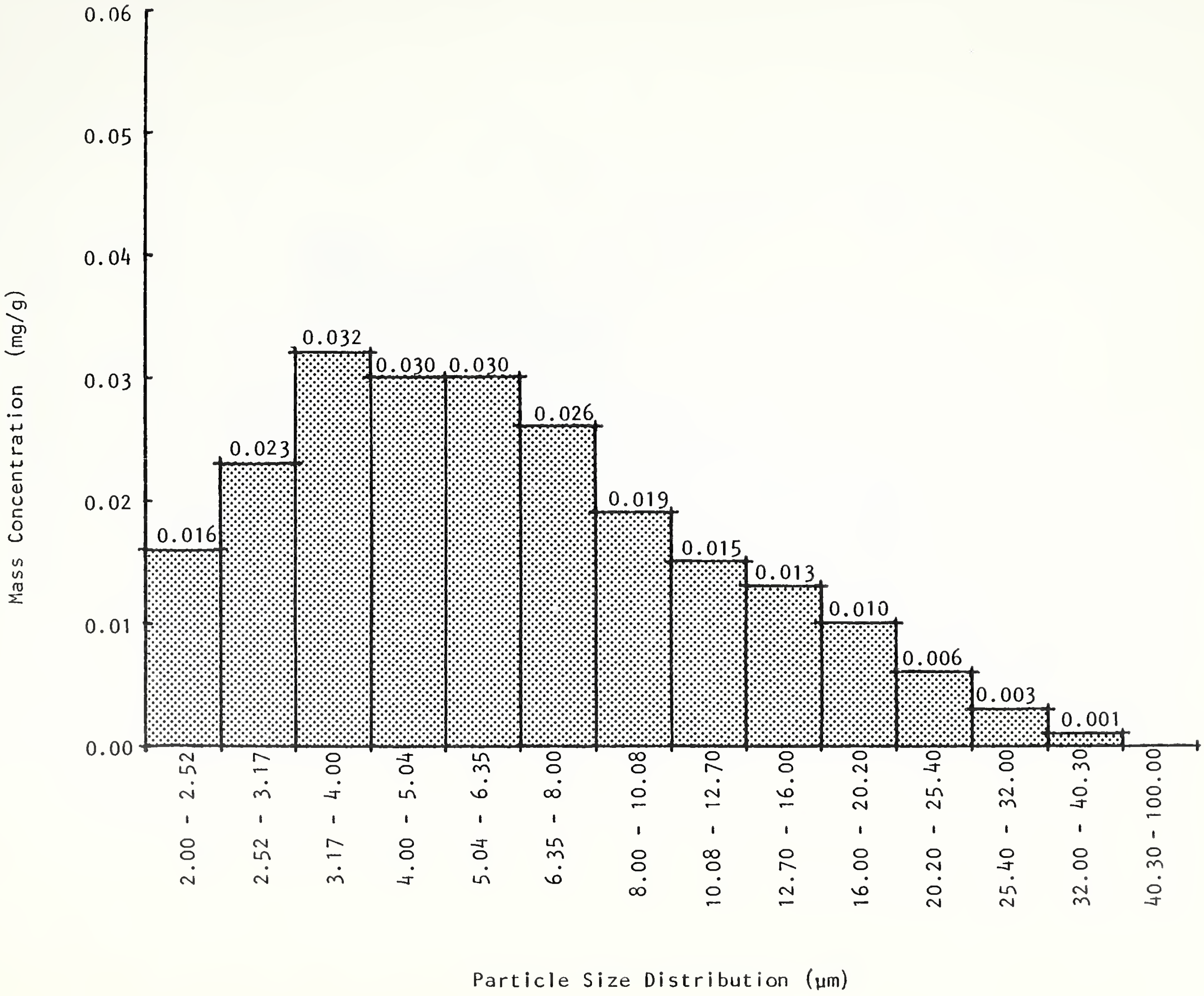
Mass Concentration - Particle Size Distribution
Mill C
P_3



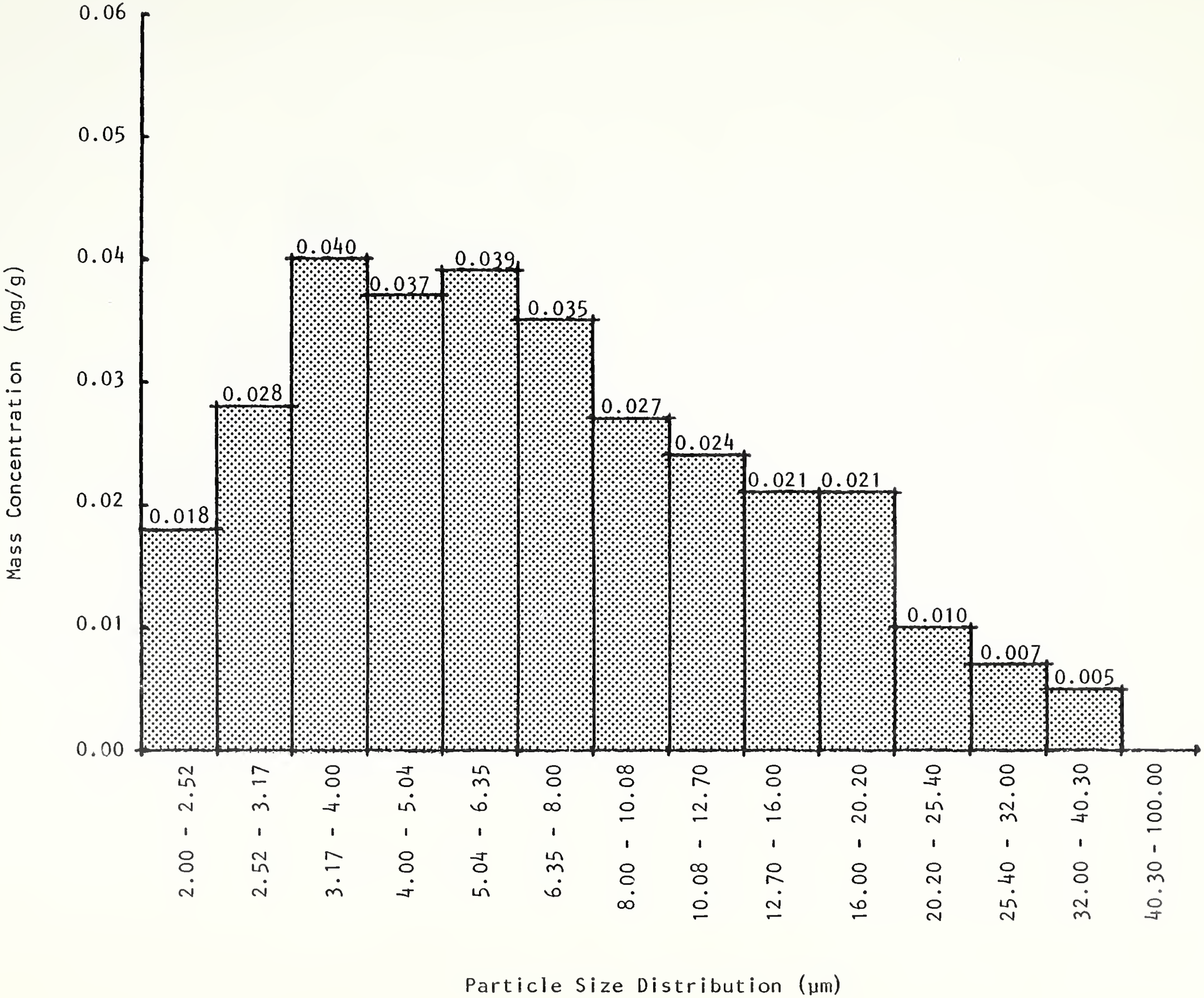
Mass Concentration - Particle Size Distribution
Mill C
P_4



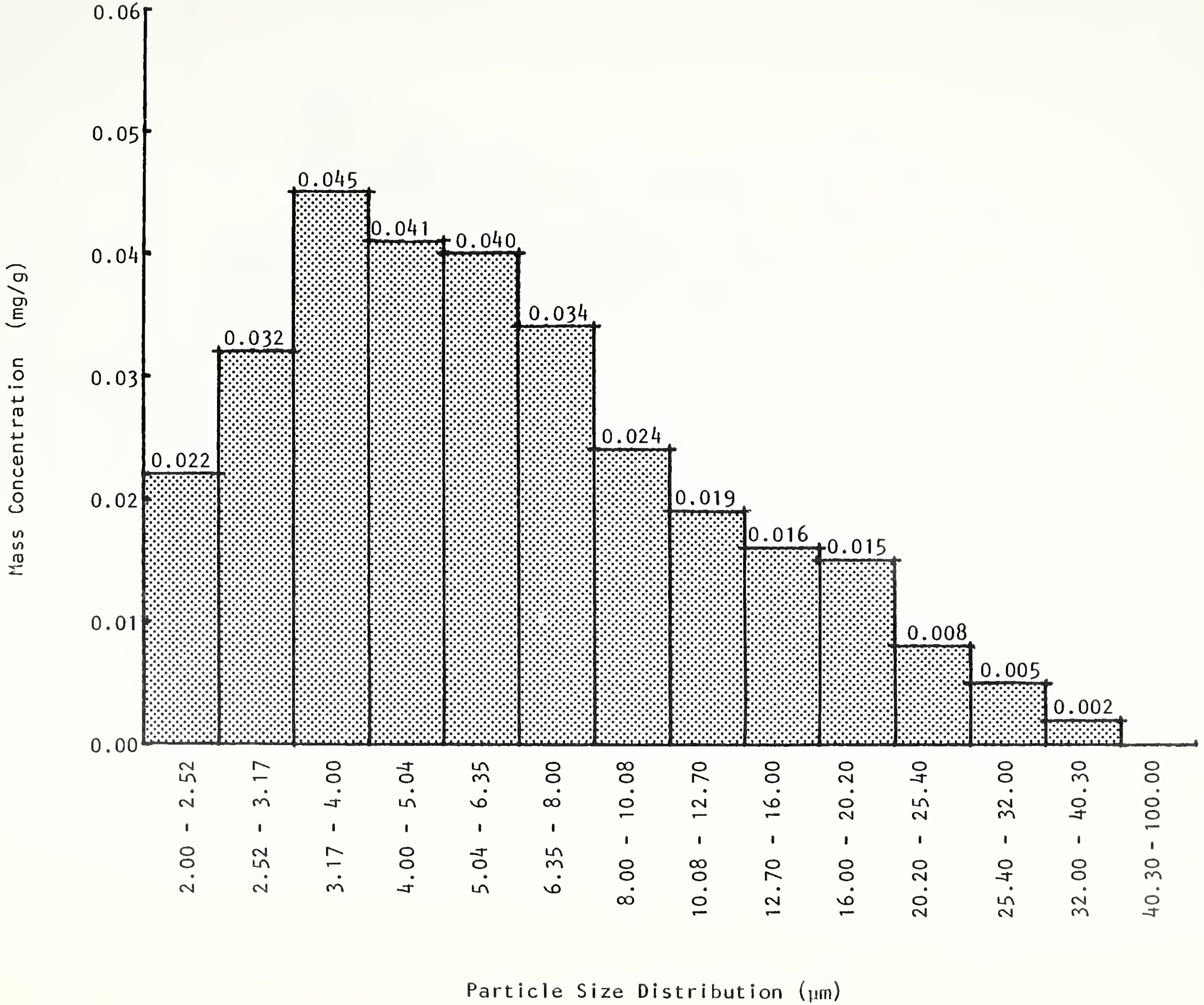
Mass Concentration - Particle Size Distribution
Mill D
P_0



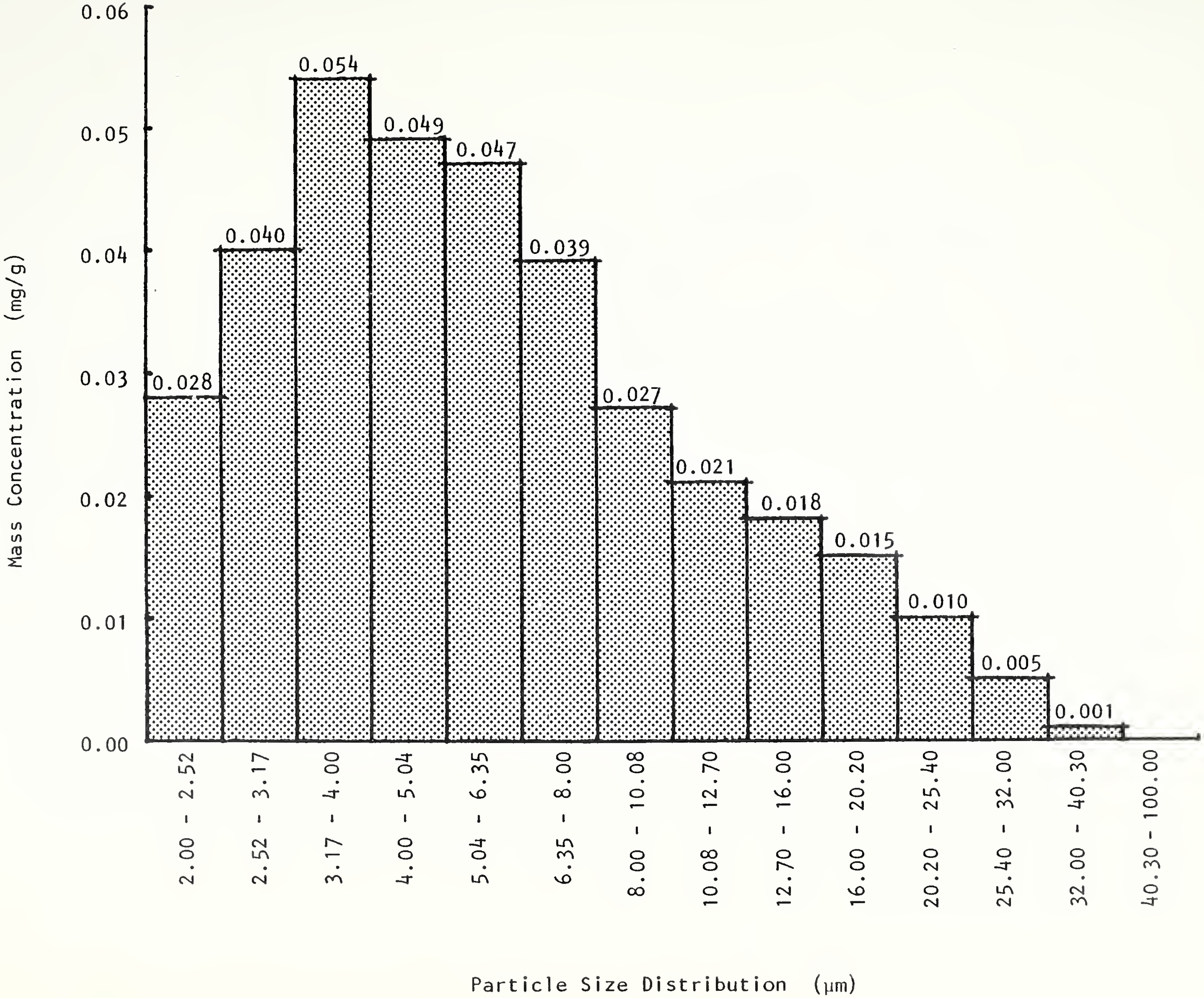
Mass Concentration - Particle Size Distribution
Mill D
P_2



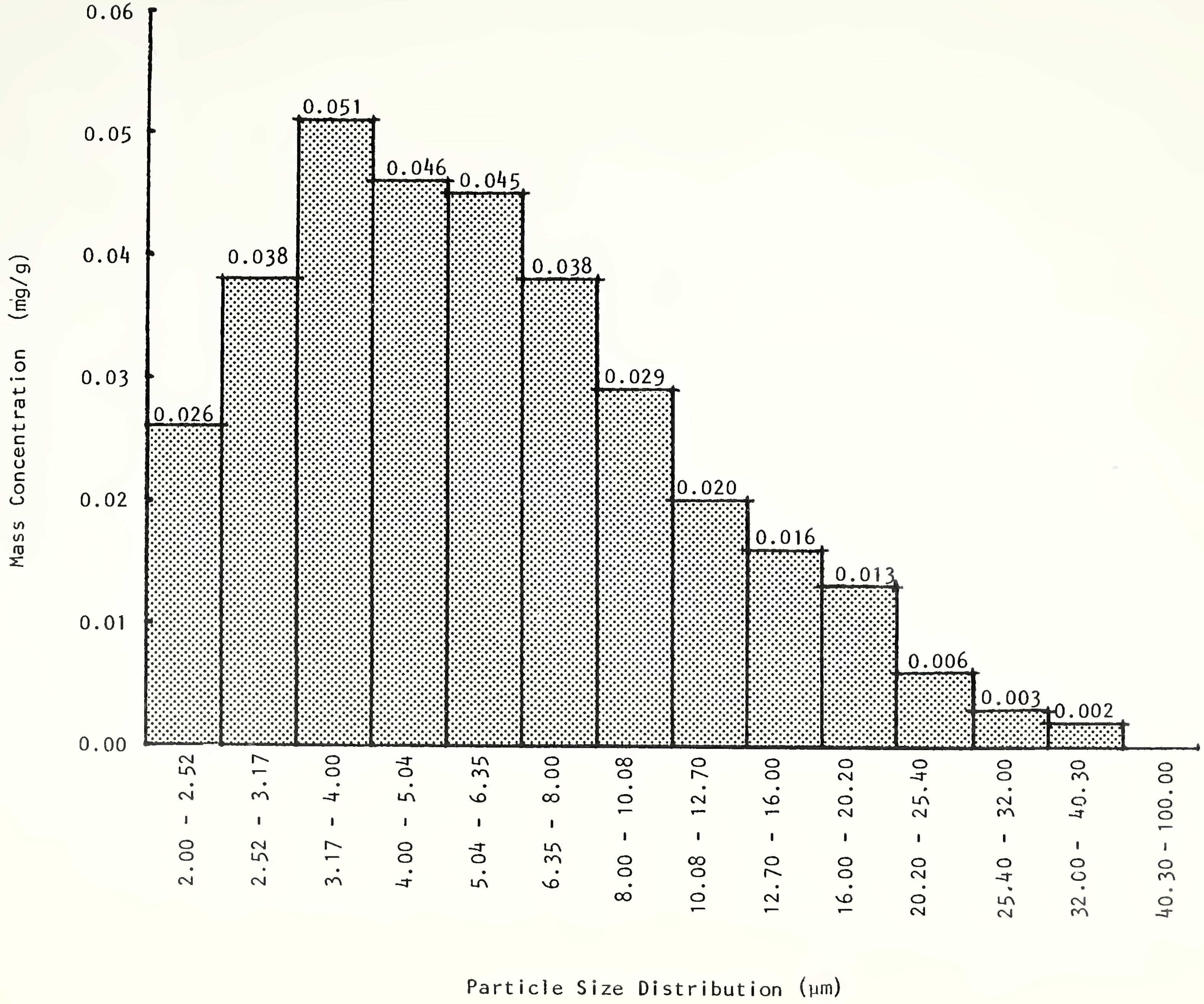
Mass Concentration - Particle Size Distribution
Mill D
P_3



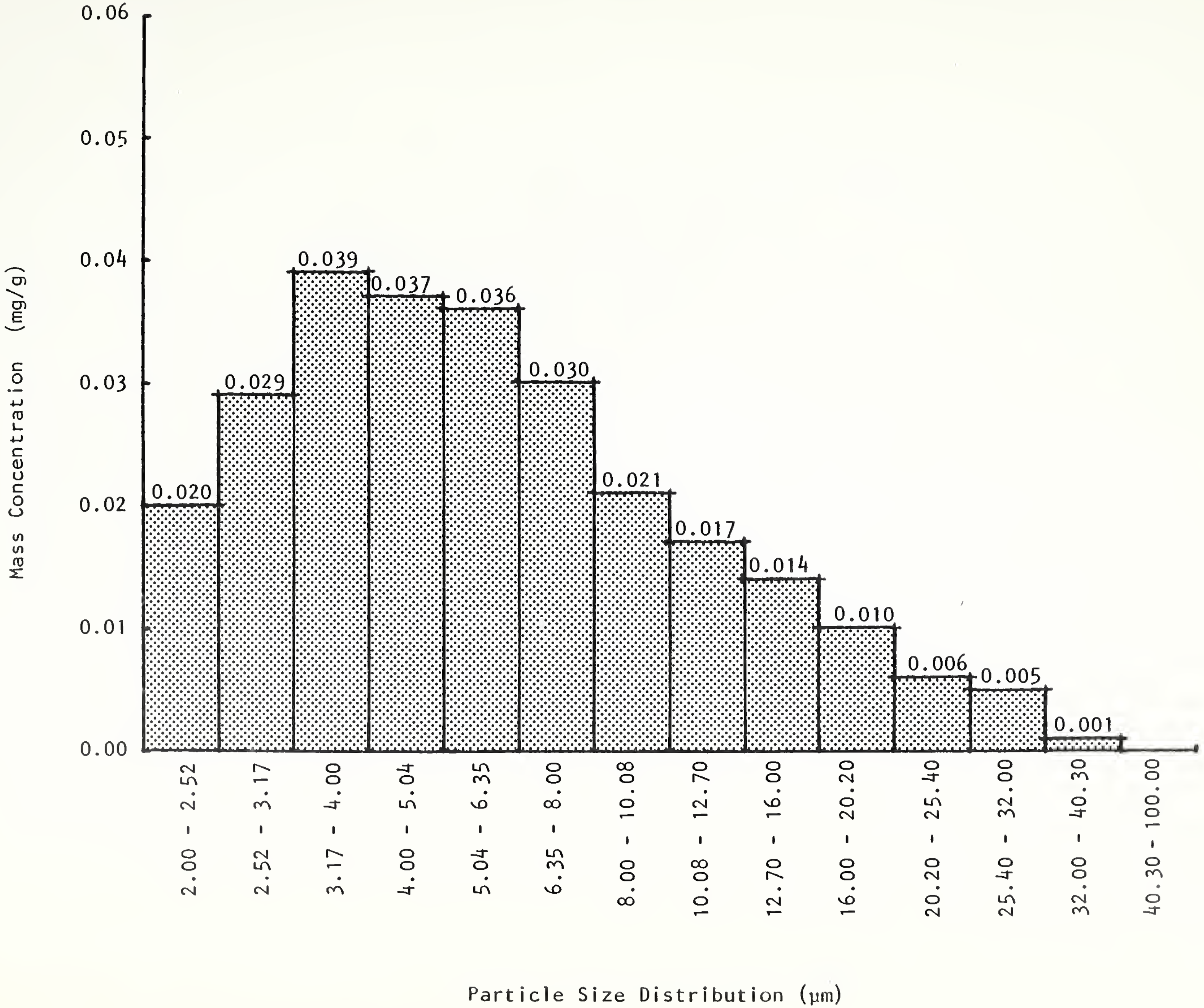
Mass Concentration - Particle Size Distribution
Mill D
P_4



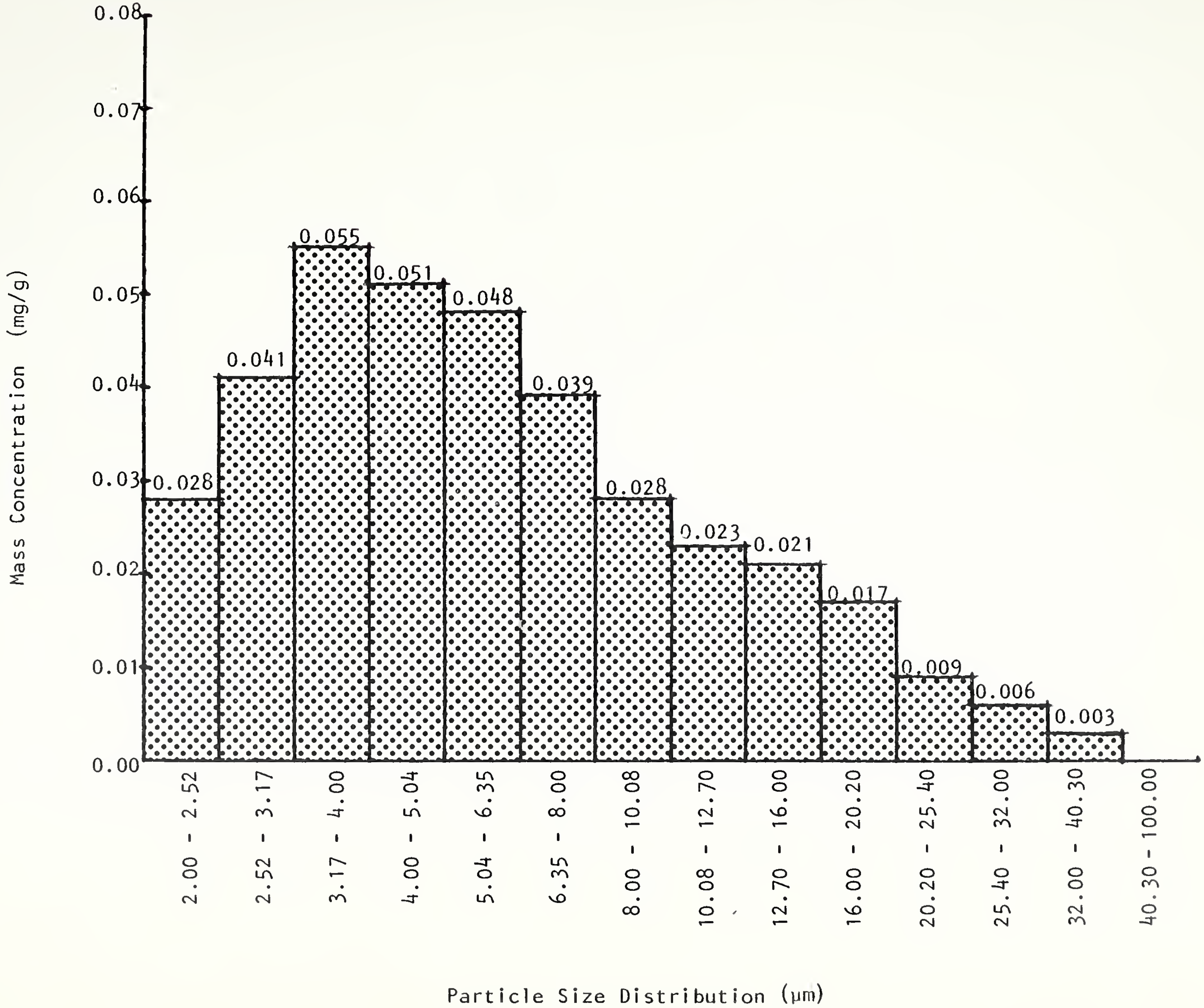
Mass Concentration - Particle Size Distribution
Mill D
P_5



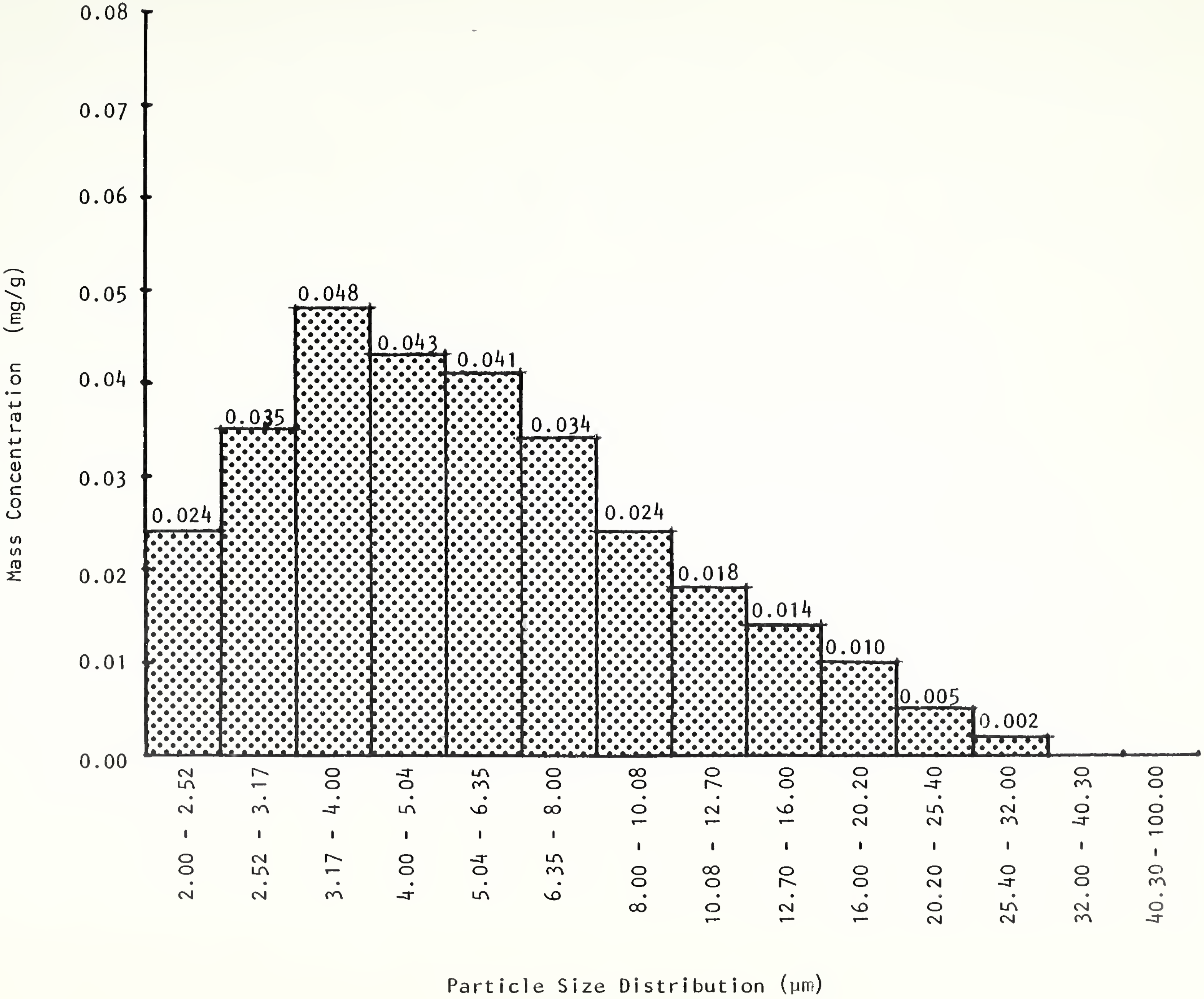
Mass Concentration - Particle Size Distribution
Mill D
P_6



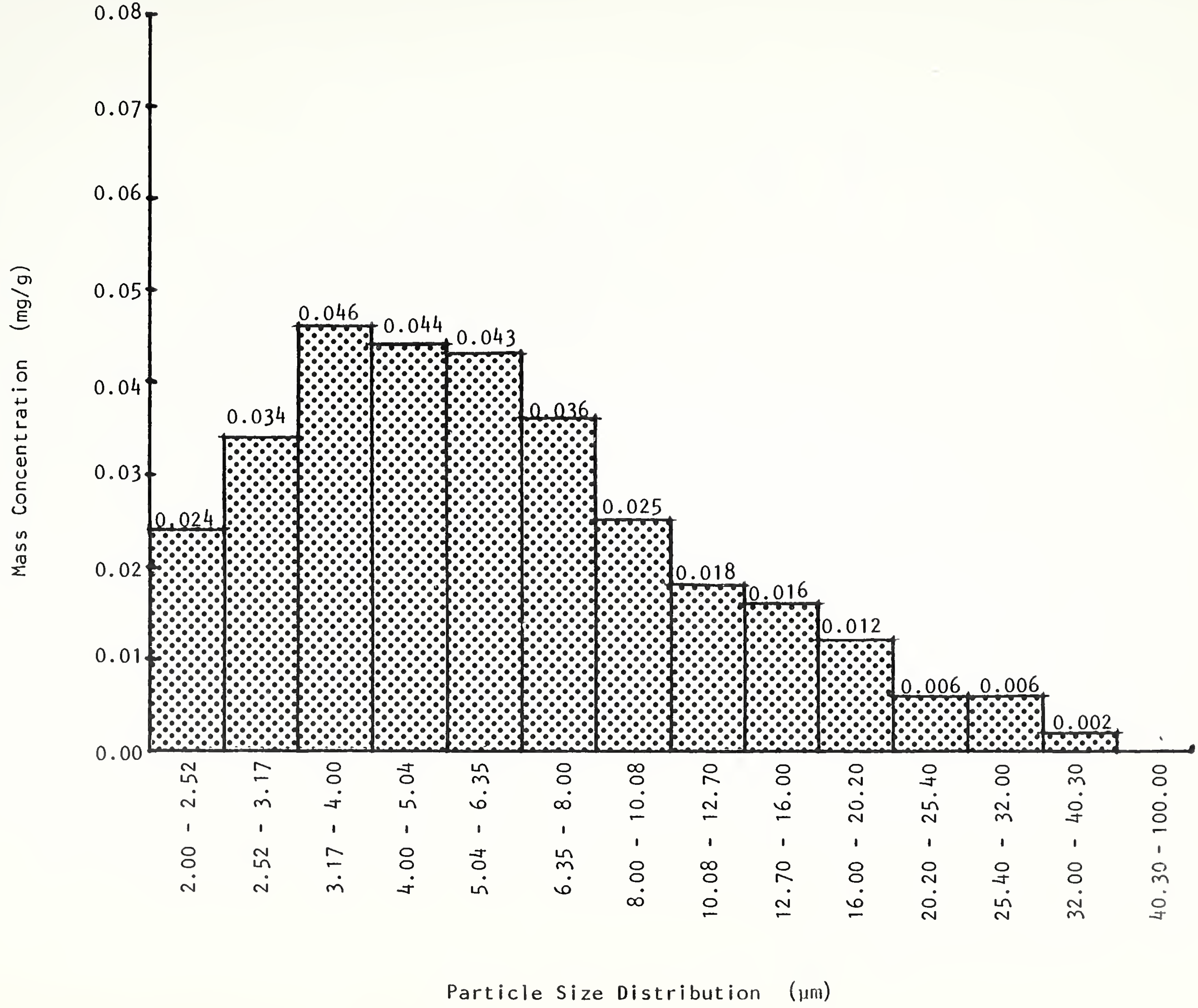
Mass Concentration - Particle Size Distribution
Mill E
P_0



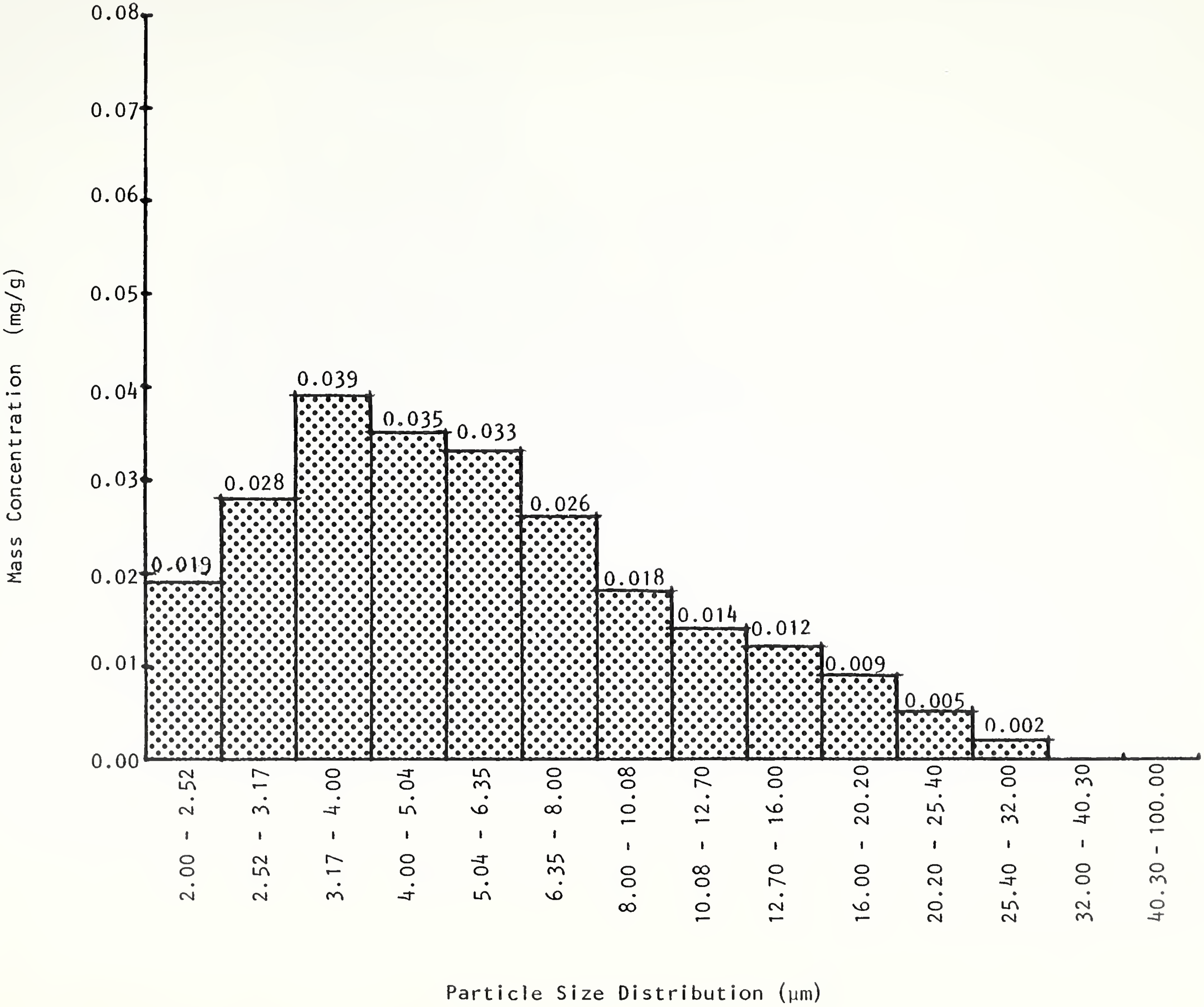
Mass Concentration - Particle Size Distribution
Mill E
P_2

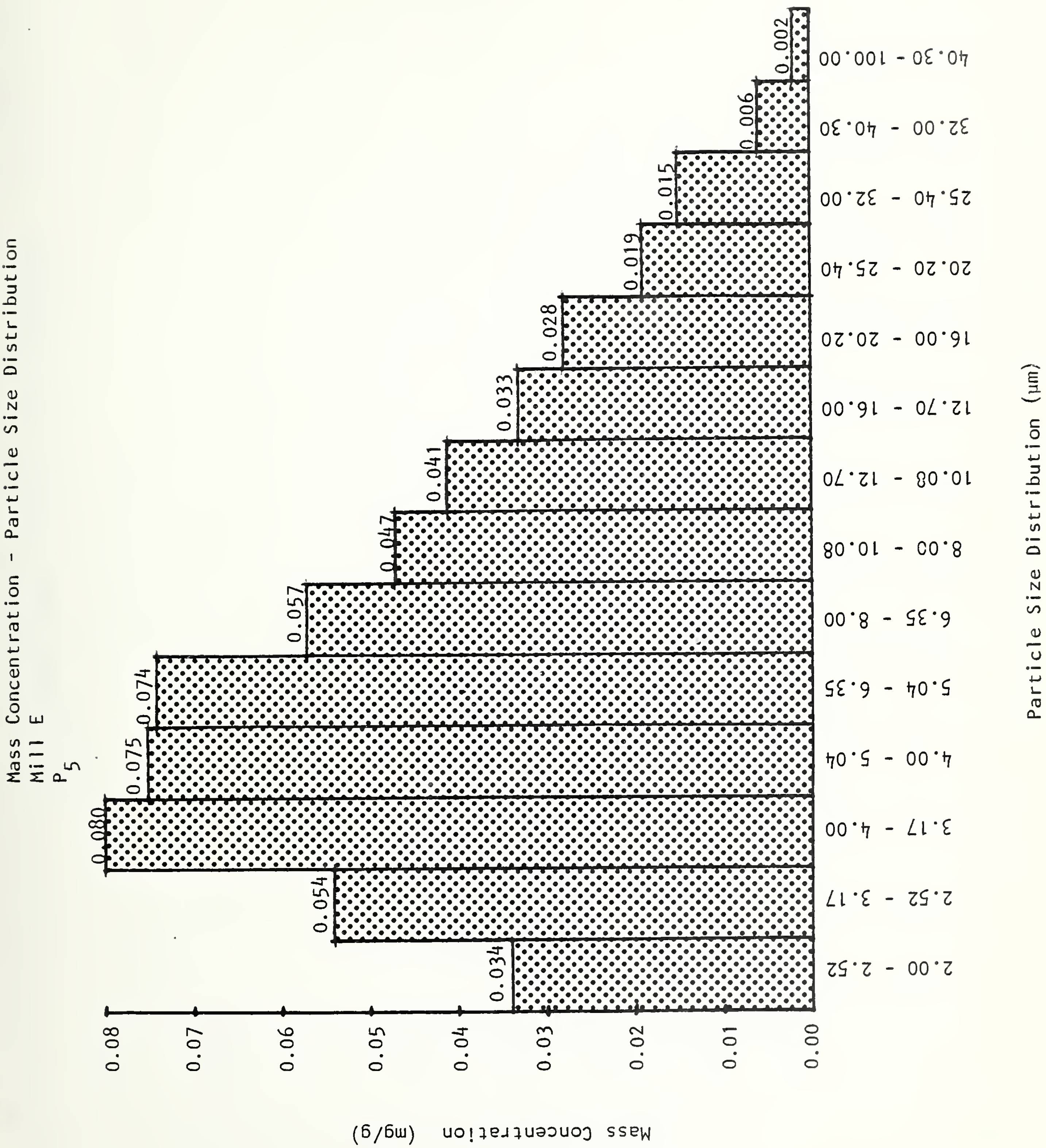


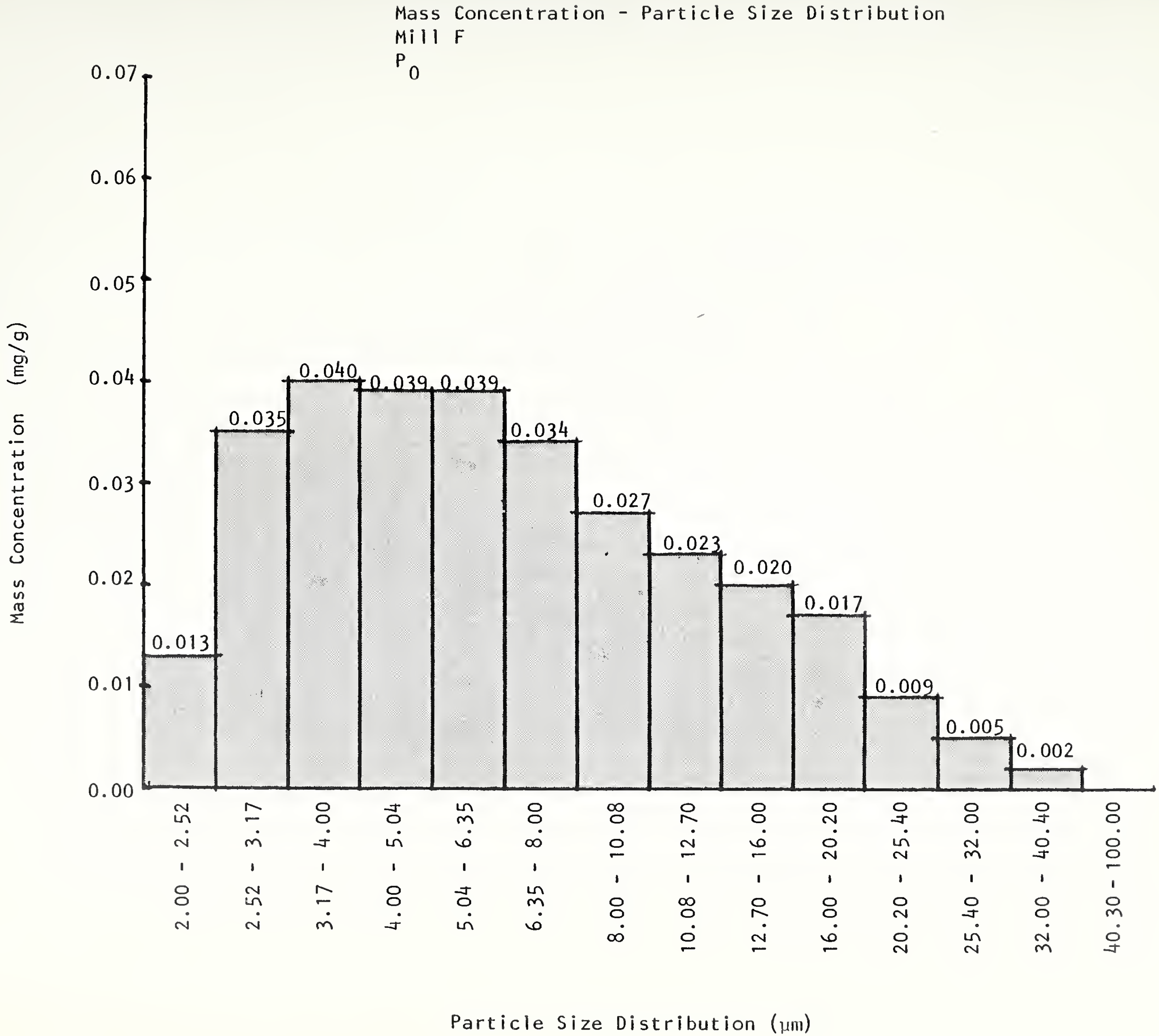
Mass Concentration - Particle Size Distribution
Mill E
P_3



Mass Concentration - Particle Size Distribution
Mill E
P_4

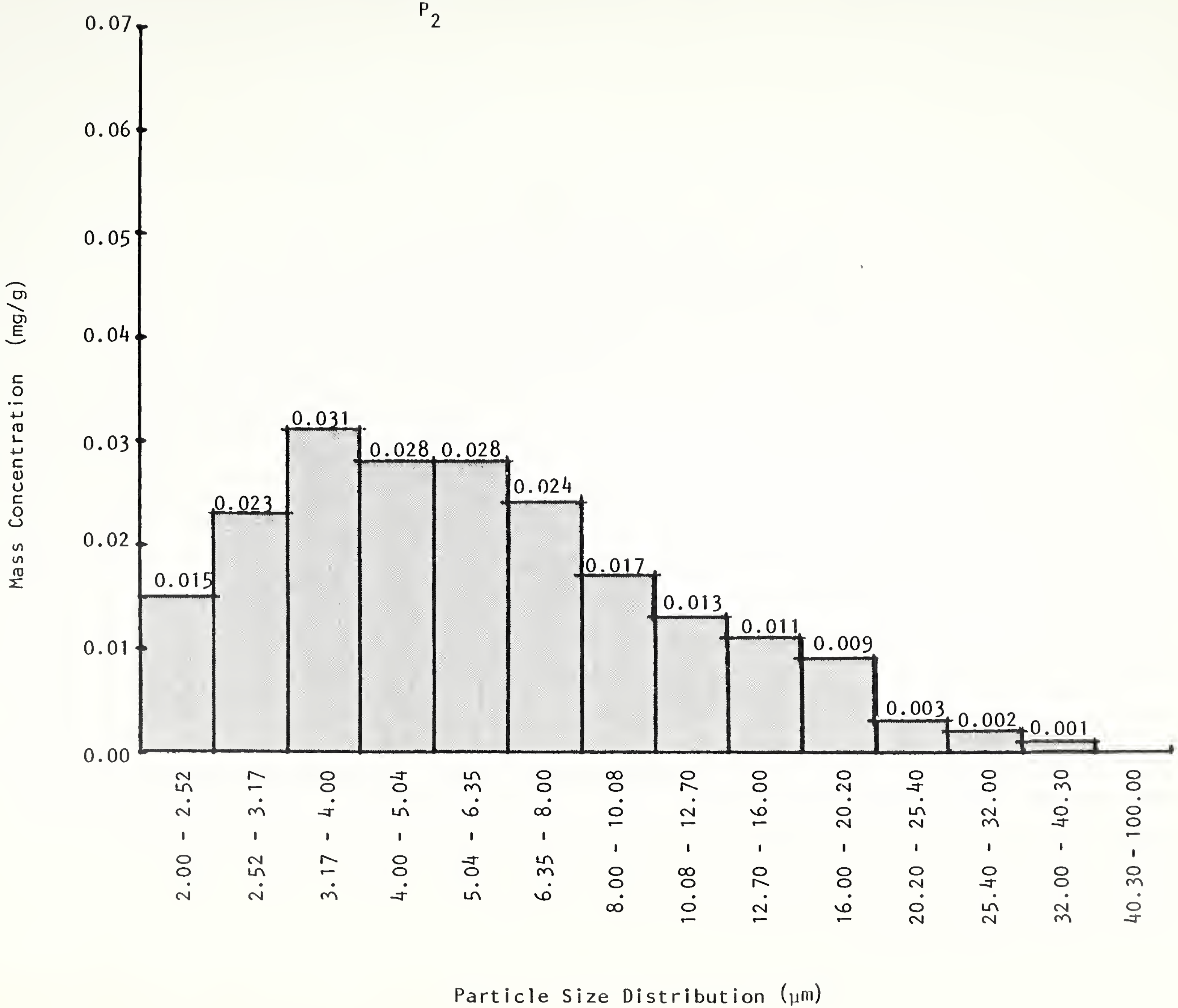



Mass Concentration - Particle Size Distribution
Mill E
P_5
Mass Concentration (mg/g)
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.034
0.054
0.080
0.075
0.074
0.057
0.047
0.041
0.033
0.028
0.019
0.015
0.006
0.002
2.00 - 2.52
2.52 - 3.17
3.17 - 4.00
4.00 - 5.04
5.04 - 6.35
6.35 - 8.00
8.00 - 10.08
10.08 - 12.70
12.70 - 16.00
16.00 - 20.20
20.20 - 25.40
25.40 - 32.00
32.00 - 40.30
40.30 - 100.00
Particle Size Distribution (μm)

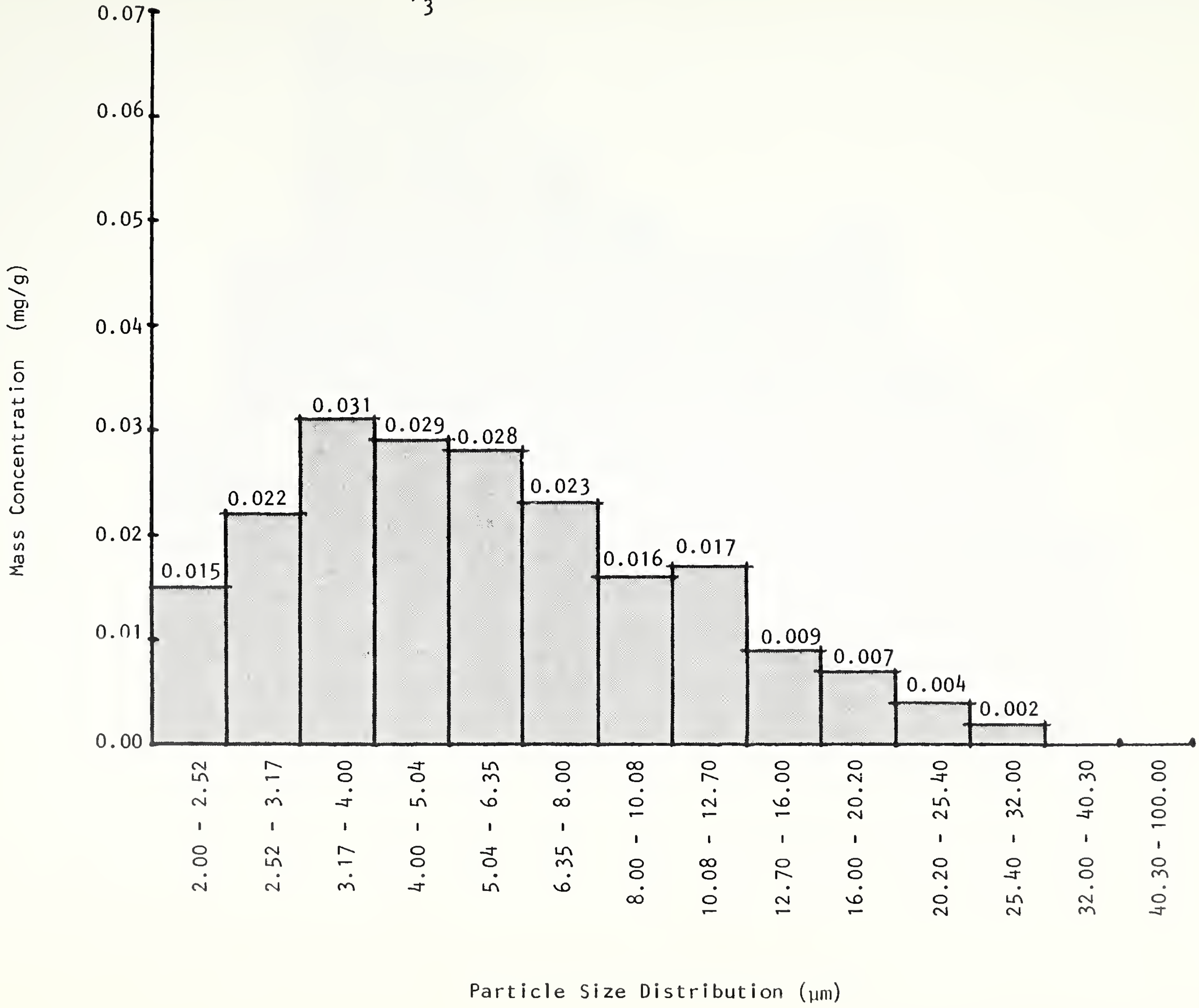


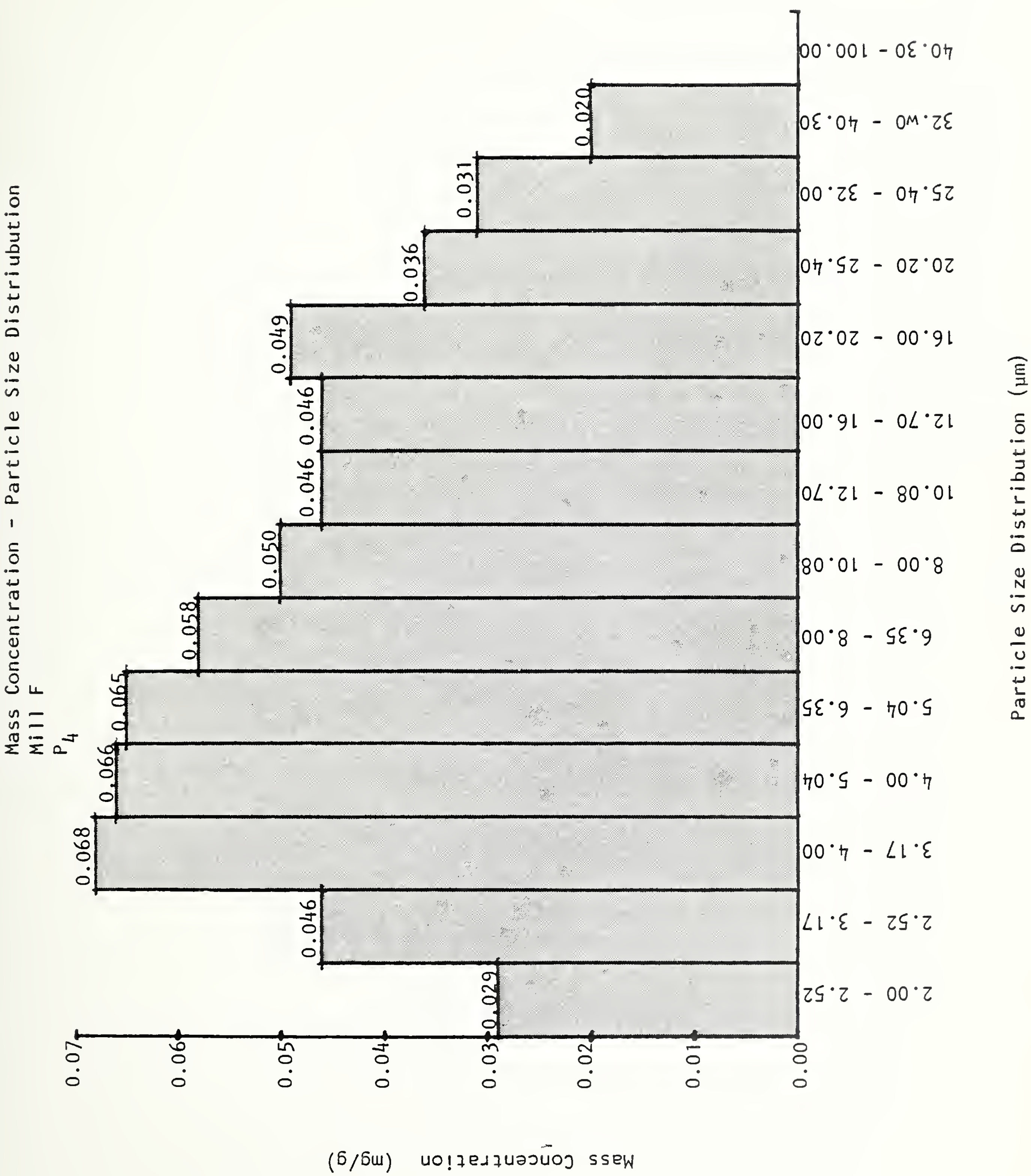
Mass Concentration - Particle Size Distribution
Mill F
P_0
Mass Concentration (mg/g)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.013
0.035
0.040
0.039
0.039
0.034
0.027
0.023
0.020
0.017
0.009
0.005
0.002
2.00 - 2.52
2.52 - 3.17
3.17 - 4.00
4.00 - 5.04
5.04 - 6.35
6.35 - 8.00
8.00 - 10.08
10.08 - 12.70
12.70 - 16.00
16.00 - 20.20
20.20 - 25.40
25.40 - 32.00
32.00 - 40.40
40.30 - 100.00
Particle Size Distribution (μm)

Mass Concentration - Particle Size Distribution
Mill F
P_2

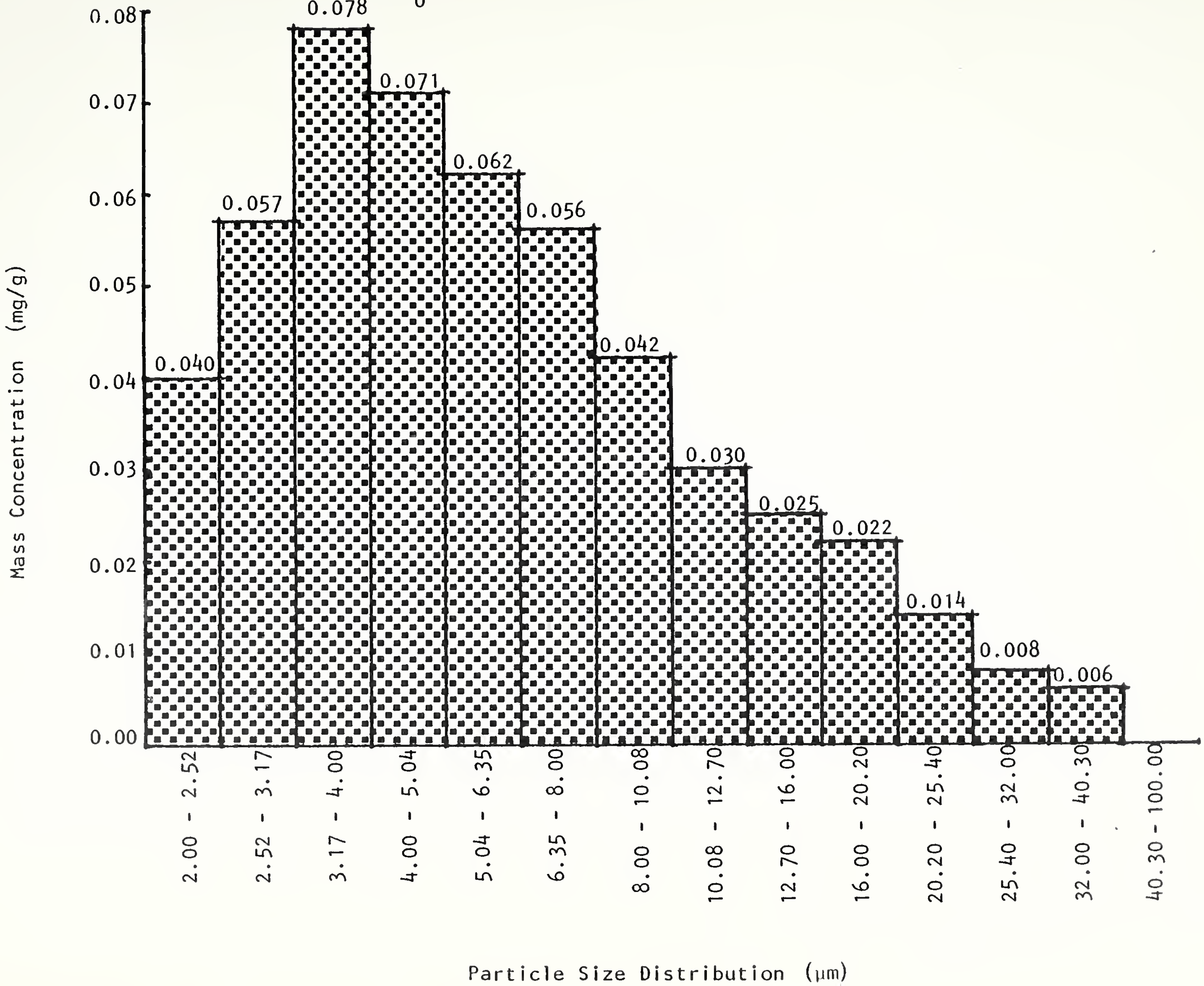


Mass Concentration - Particle Size Distribution
Mill F
P_3

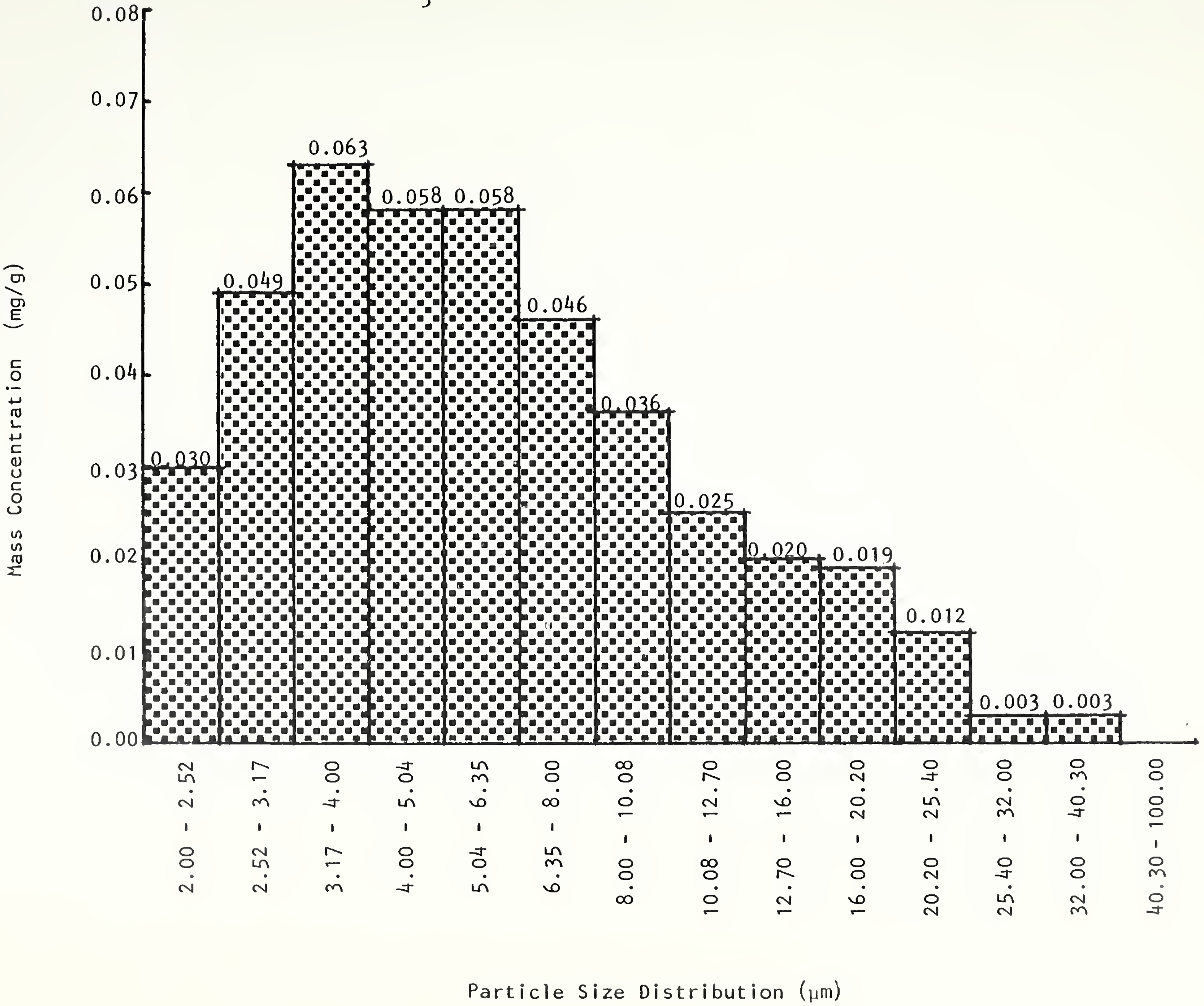



Mass Concentration - Particle Size Distriubution
Mill F
P_4
0.029
0.046
0.068
0.066
0.065
0.058
0.050
0.046
0.046
0.049
0.036
0.031
0.020
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Mass Concentration (mg/g)
2.00 - 2.52
2.52 - 3.17
3.17 - 4.00
4.00 - 5.04
5.04 - 6.35
6.35 - 8.00
8.00 - 10.08
10.08 - 12.70
12.70 - 16.00
16.00 - 20.20
20.20 - 25.40
25.40 - 32.00
32.w0 - 40.30
40.30 - 100.00
Particle Size Distribution (µm)

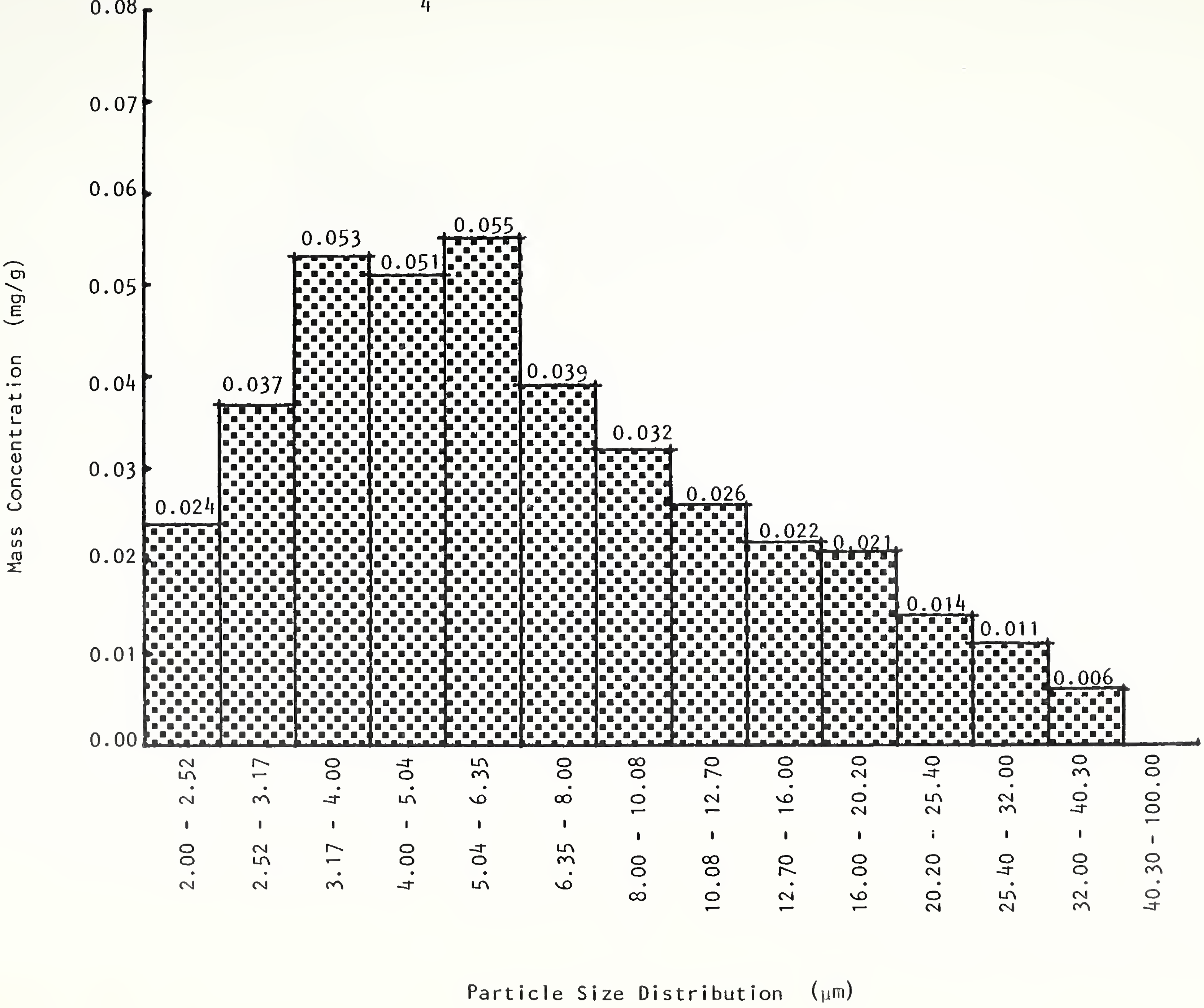
Mass Concentration - Particle Size Distribution
Mill G
P_0



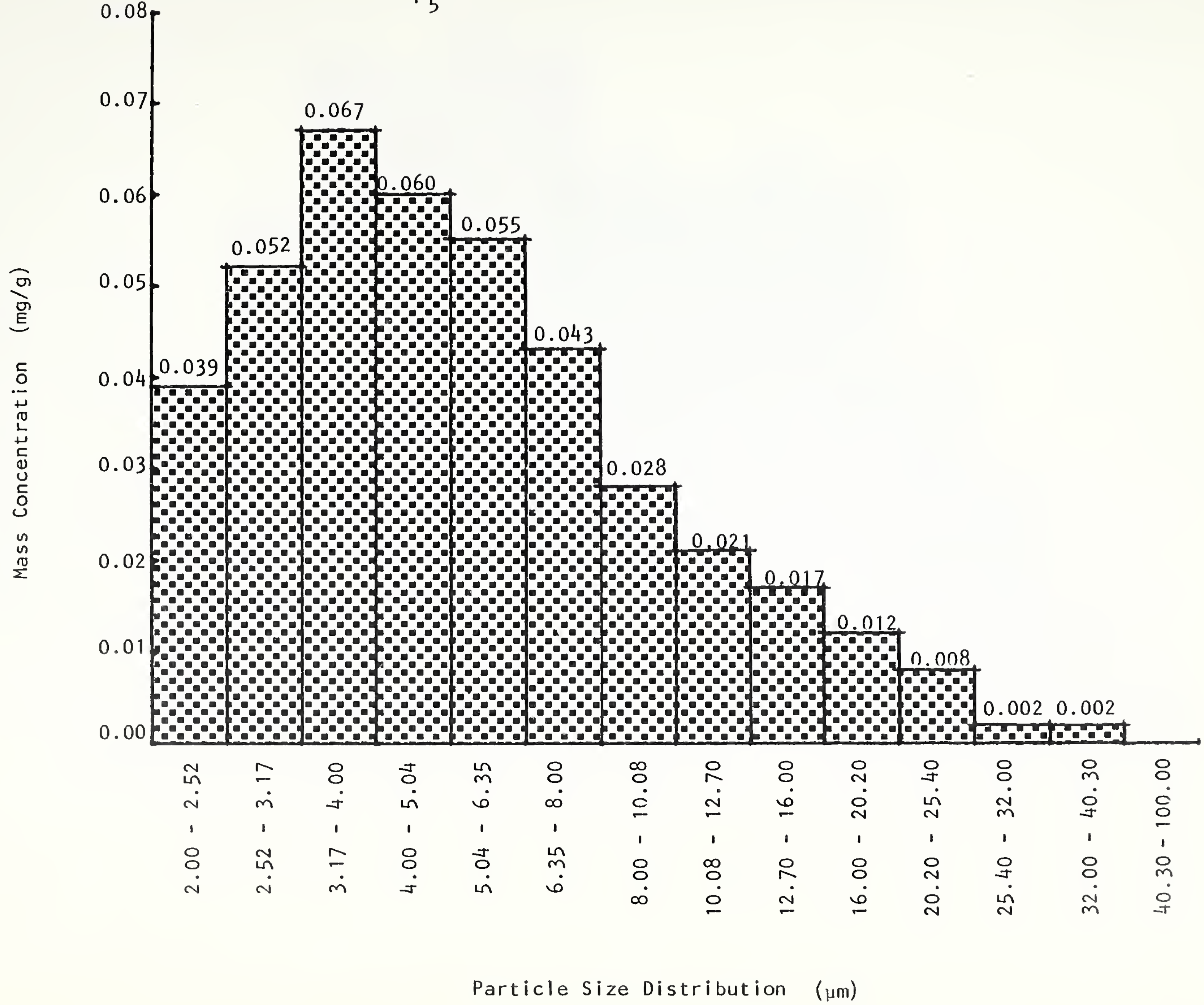
Mass Concentration - Particle Size Distribution
Mill G
P_3

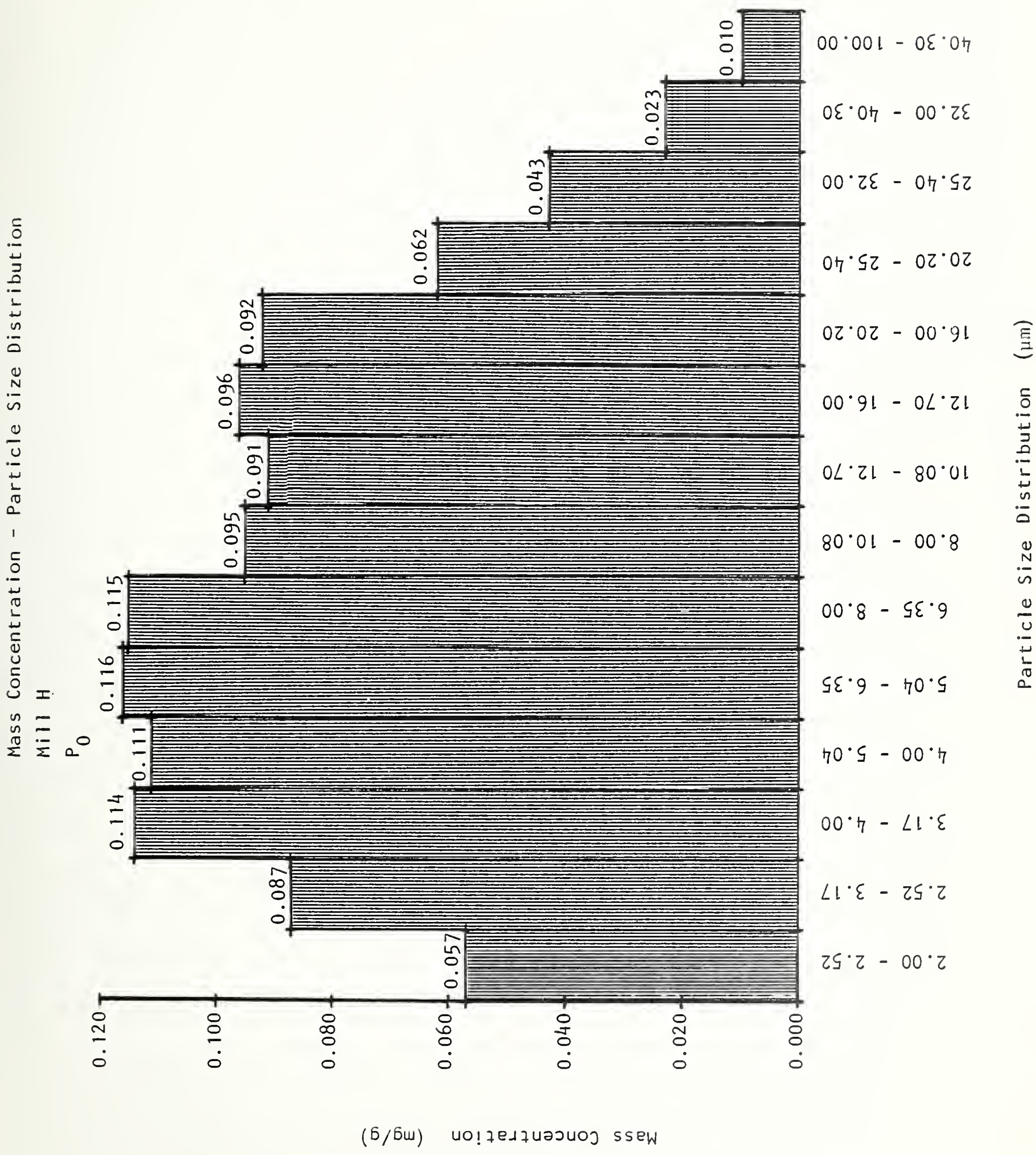


Mass Concentration - Particle Size Distribution
Mill G
P_4



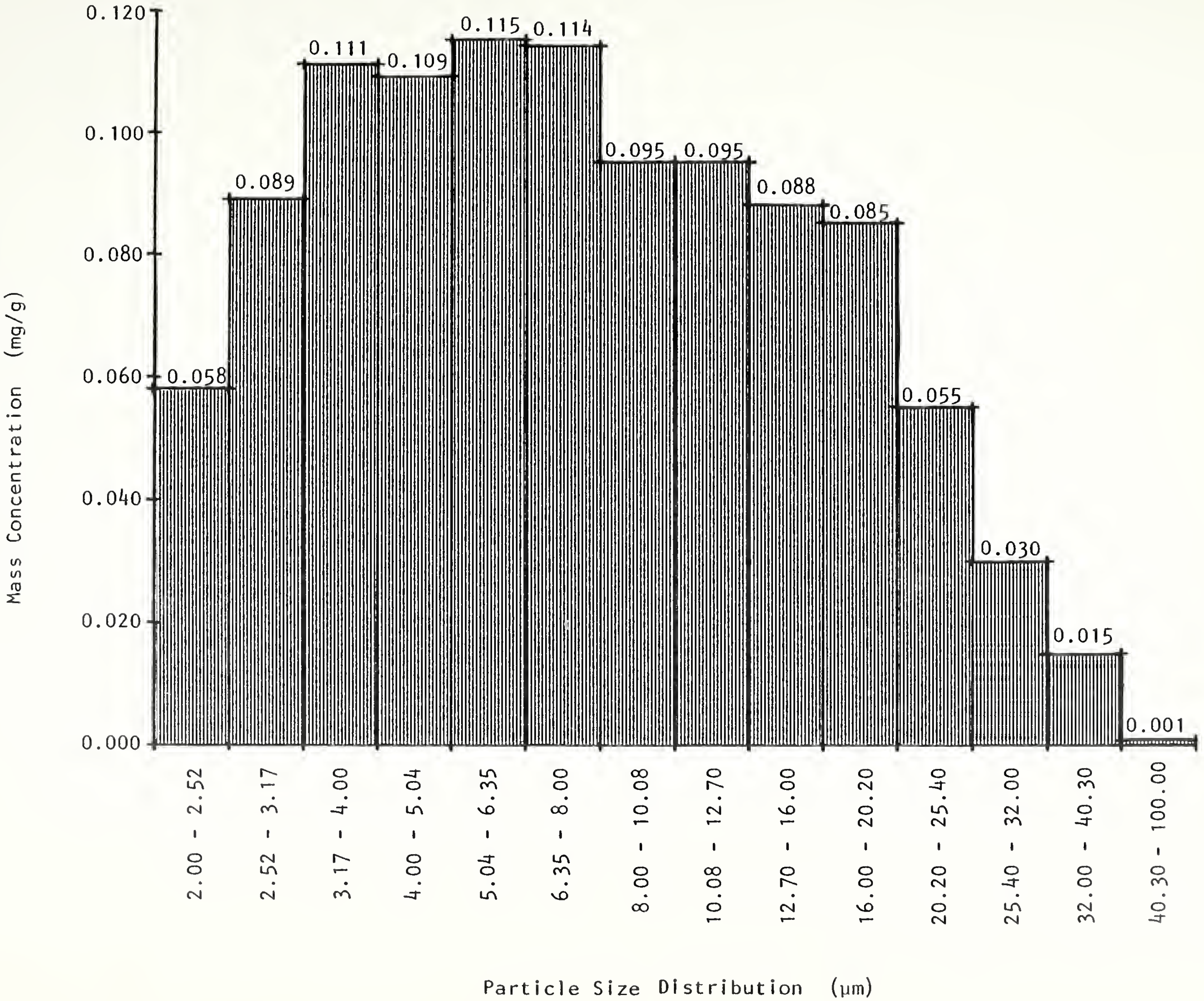
Mass Concentration - Particle Size Distribution
Mill G
P_5



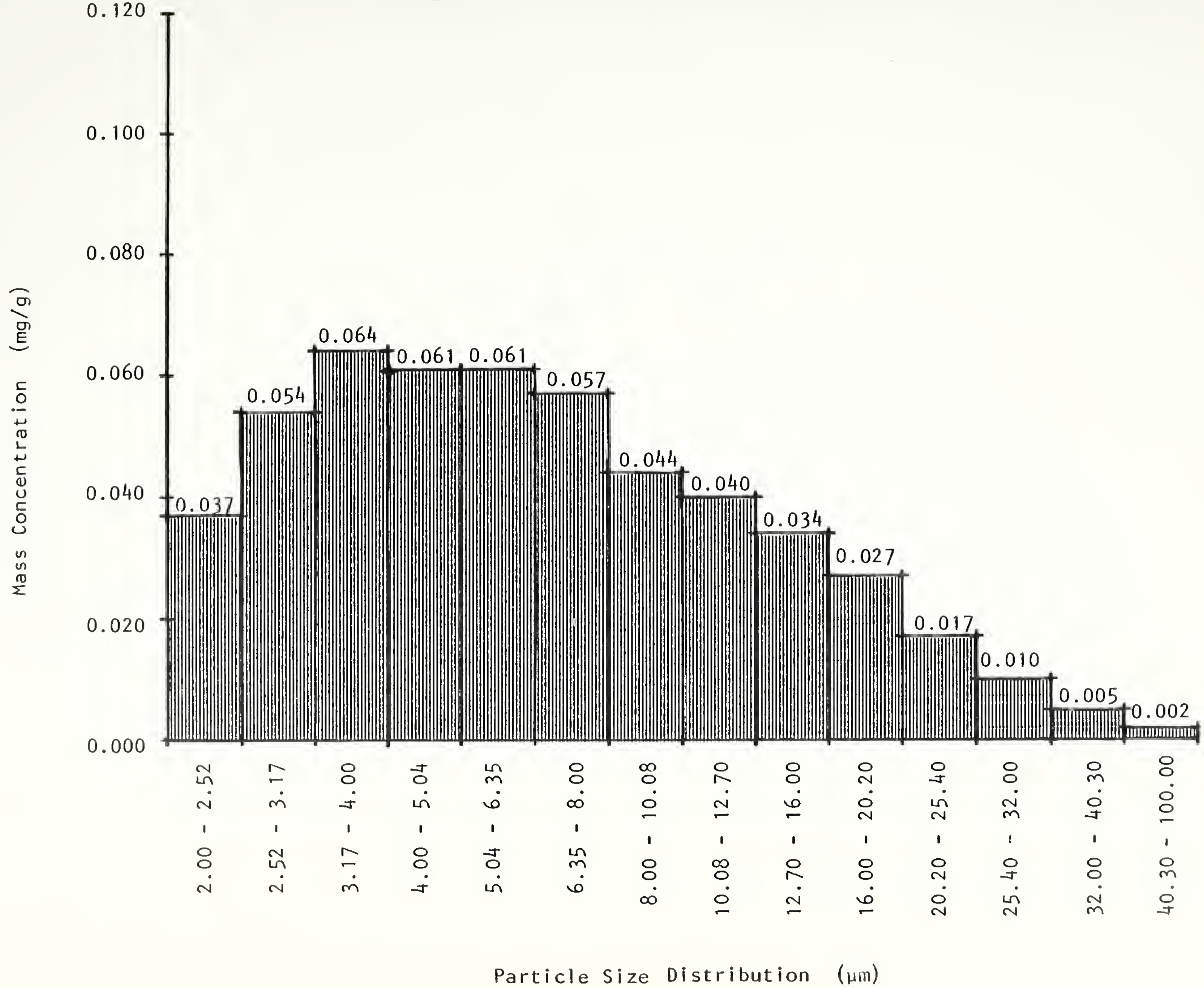


Mass Concentration - Particle Size Distribution
Mill H
P0
Mass Concentration (mg/g)
0.120
0.100
0.080
0.060
0.040
0.020
0.000
Particle Size Distribution (μm)
2.00 - 2.52
2.52 - 3.17
3.17 - 4.00
4.00 - 5.04
5.04 - 6.35
6.35 - 8.00
8.00 - 10.08
10.08 - 12.70
12.70 - 16.00
16.00 - 20.20
20.20 - 25.40
25.40 - 32.00
32.00 - 40.30
40.30 - 100.00
0.057
0.087
0.114
0.111
0.116
0.115
0.095
0.091
0.096
0.092
0.062
0.043
0.023
0.010

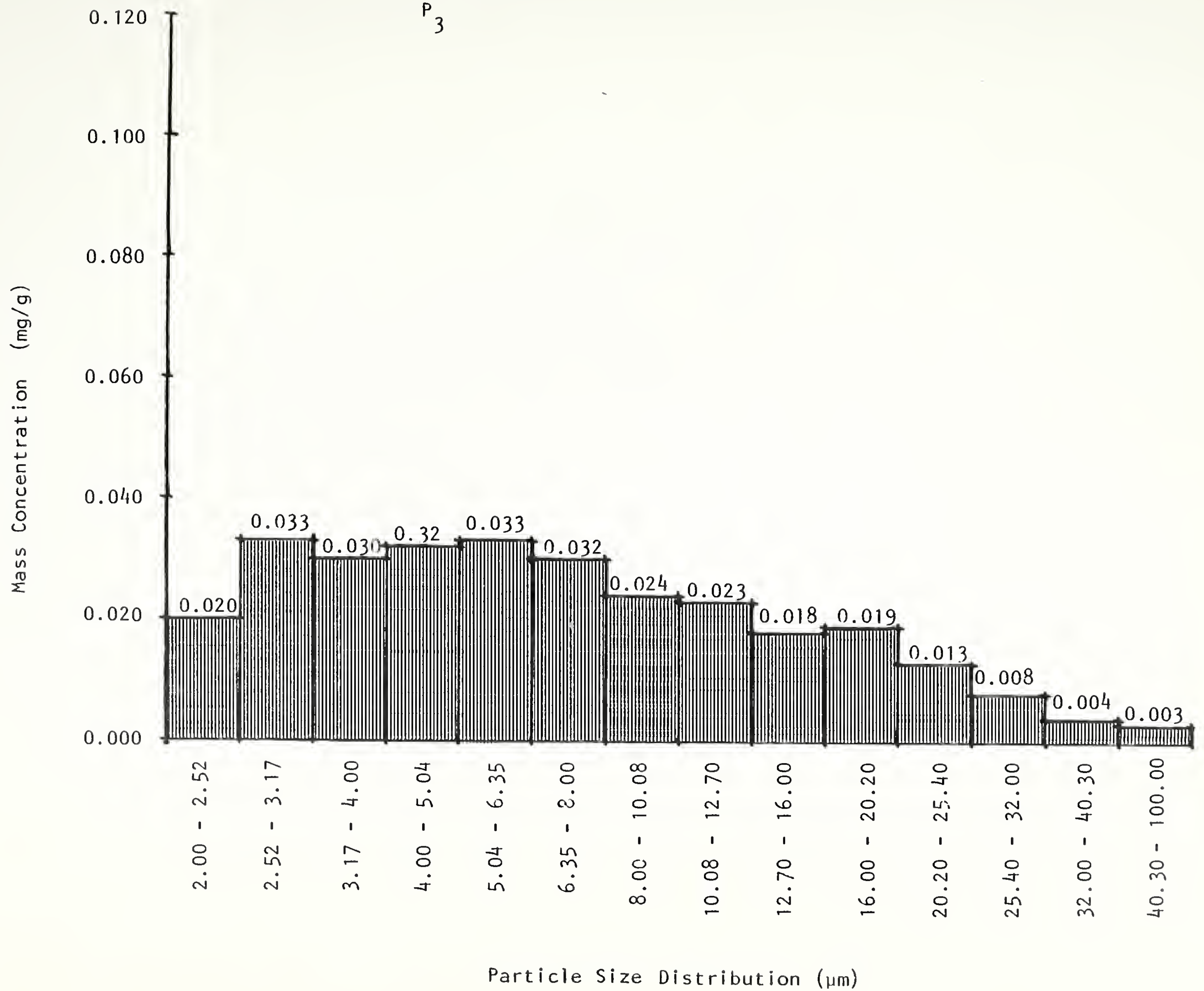
Mass Concentration - Particle Size Distribution
Mill H
P_1



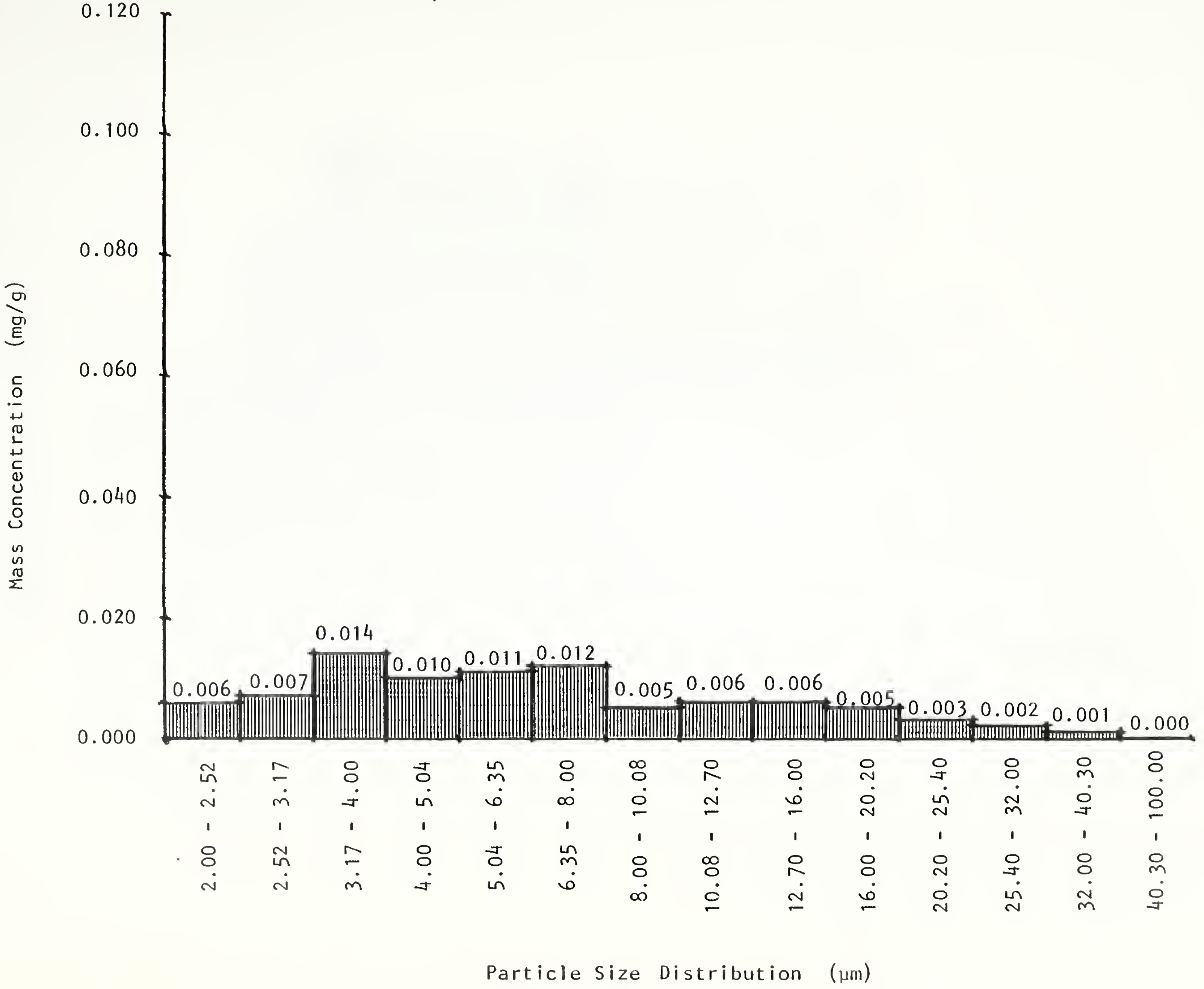
Mass Concentration - Particle Size Distribution
Mill H
P_2



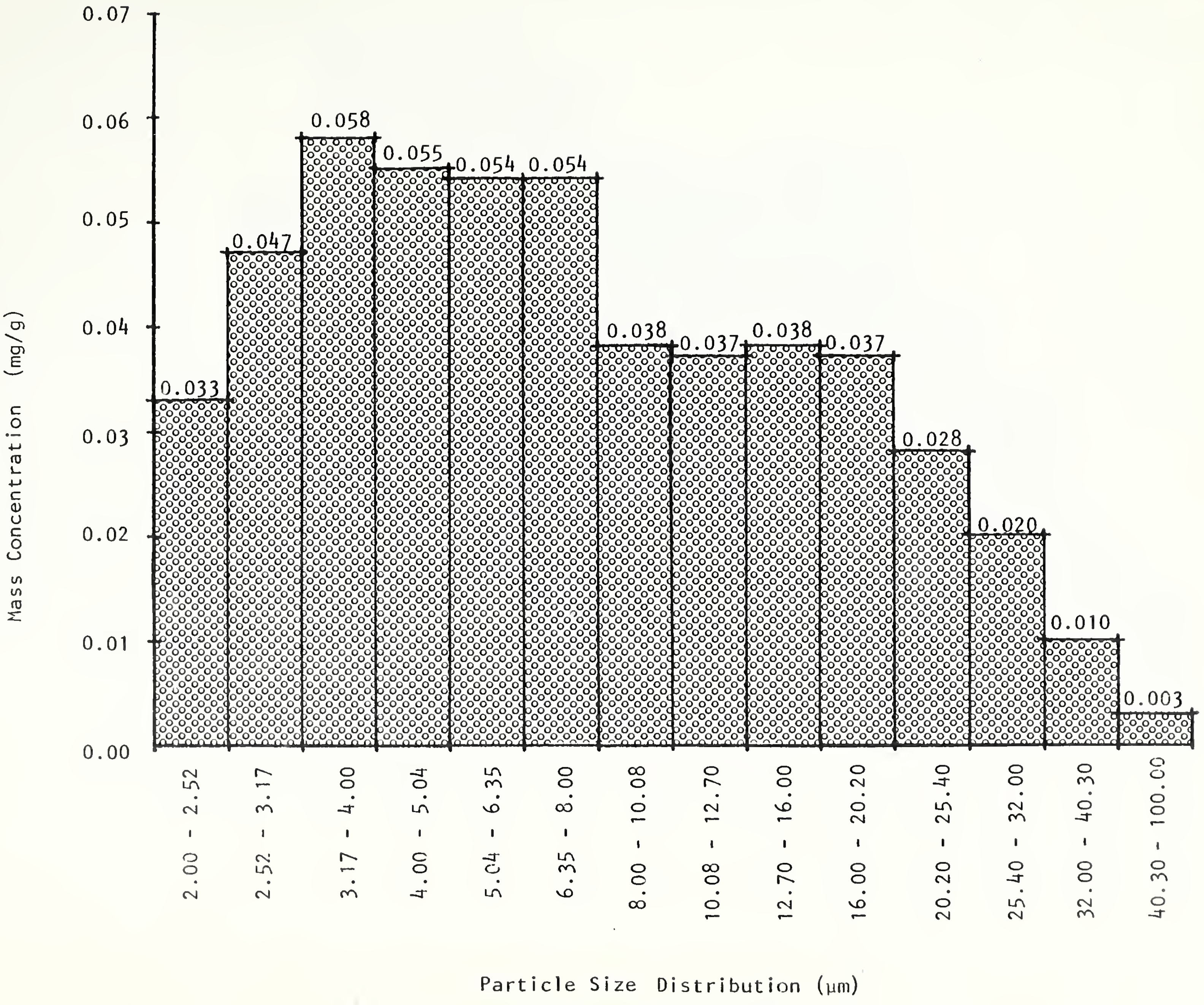
Mass Concentration - Particle Size Distribution
Mill H
P_3



Mass Concentration - Particle Size Distribution
Mill H
P_4



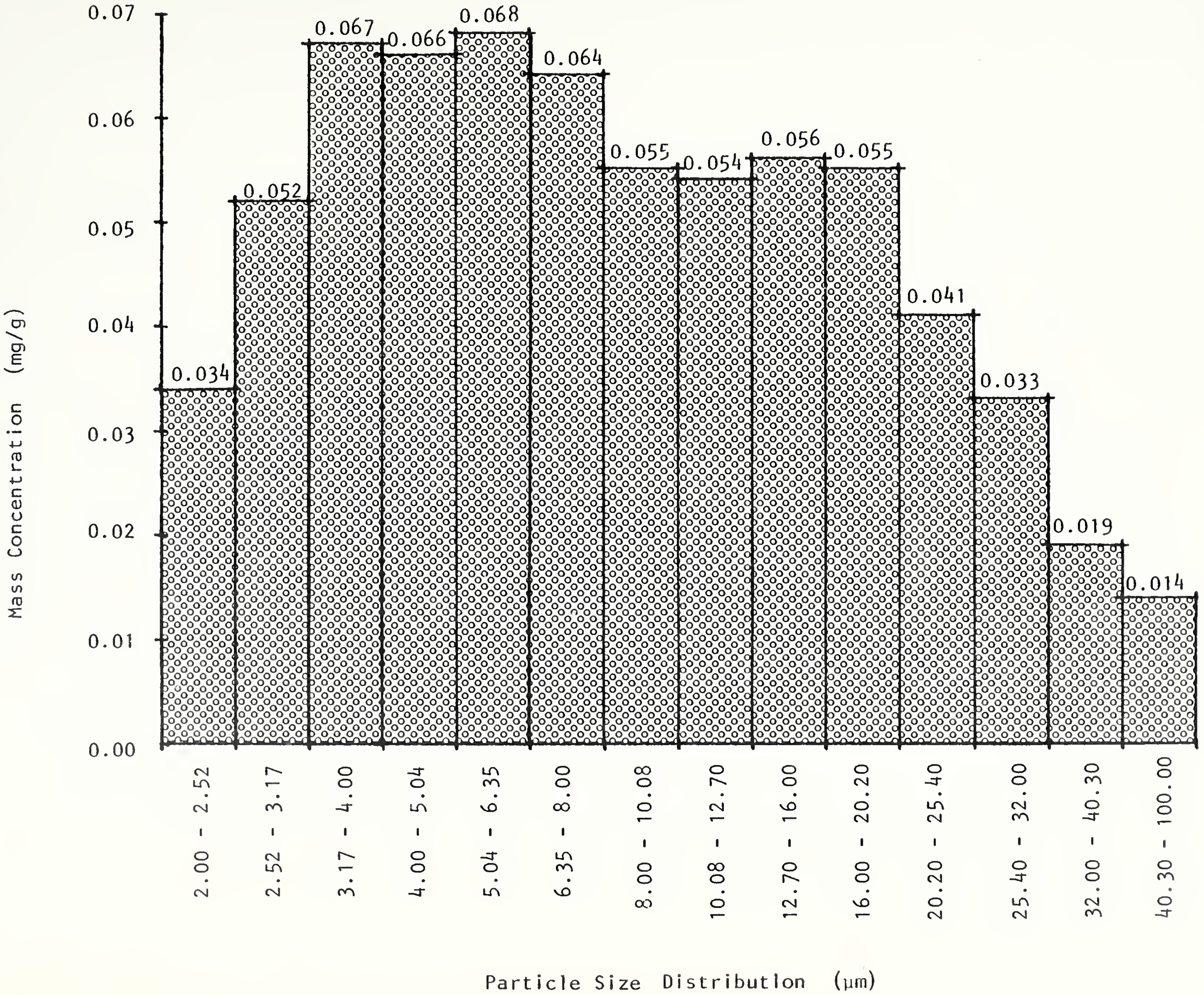
Mass Concentration - Particle Size Distribution
Mill I
P_0



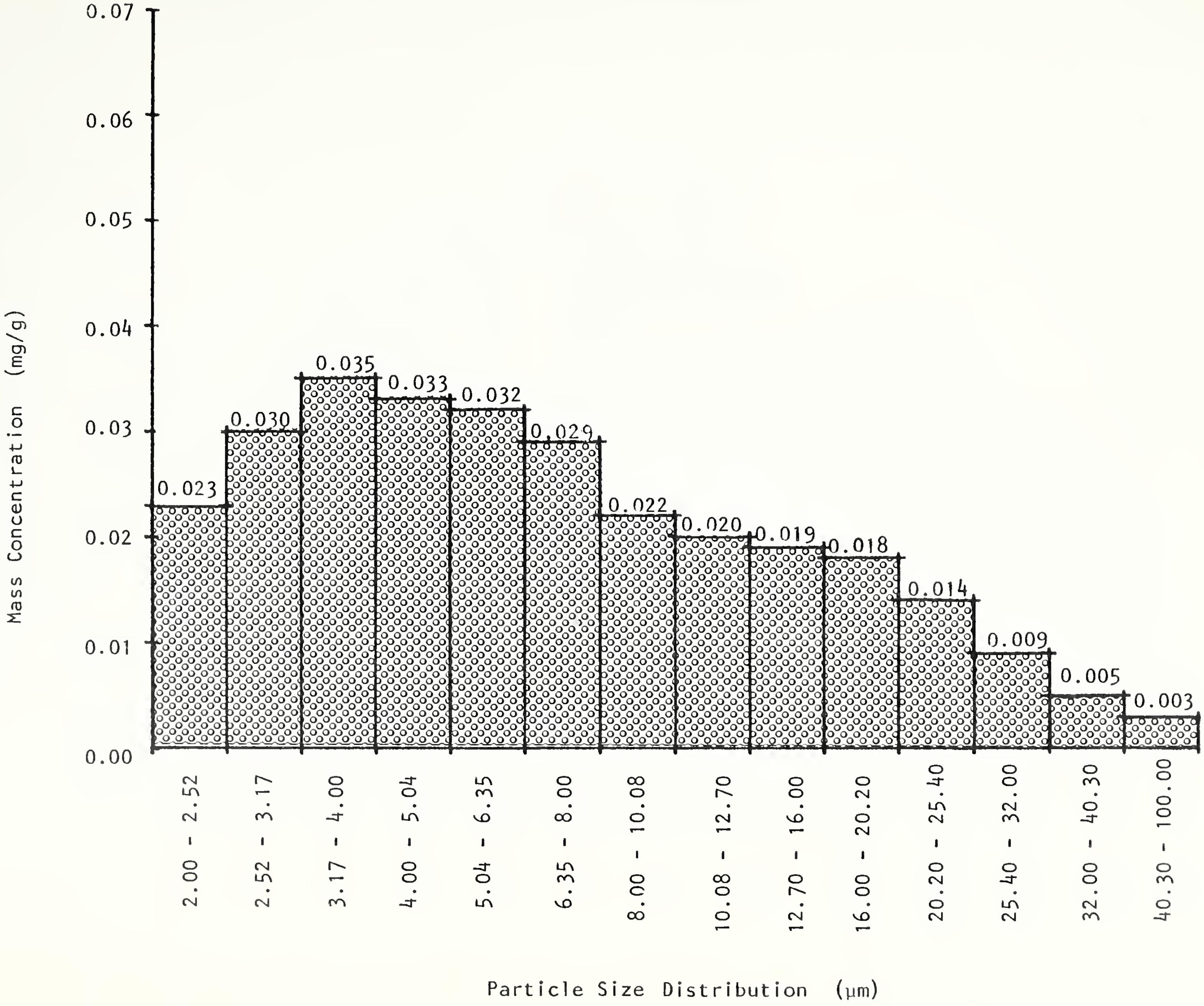
Mass Concentration - Particle Size Distribution

Mill I

P_2



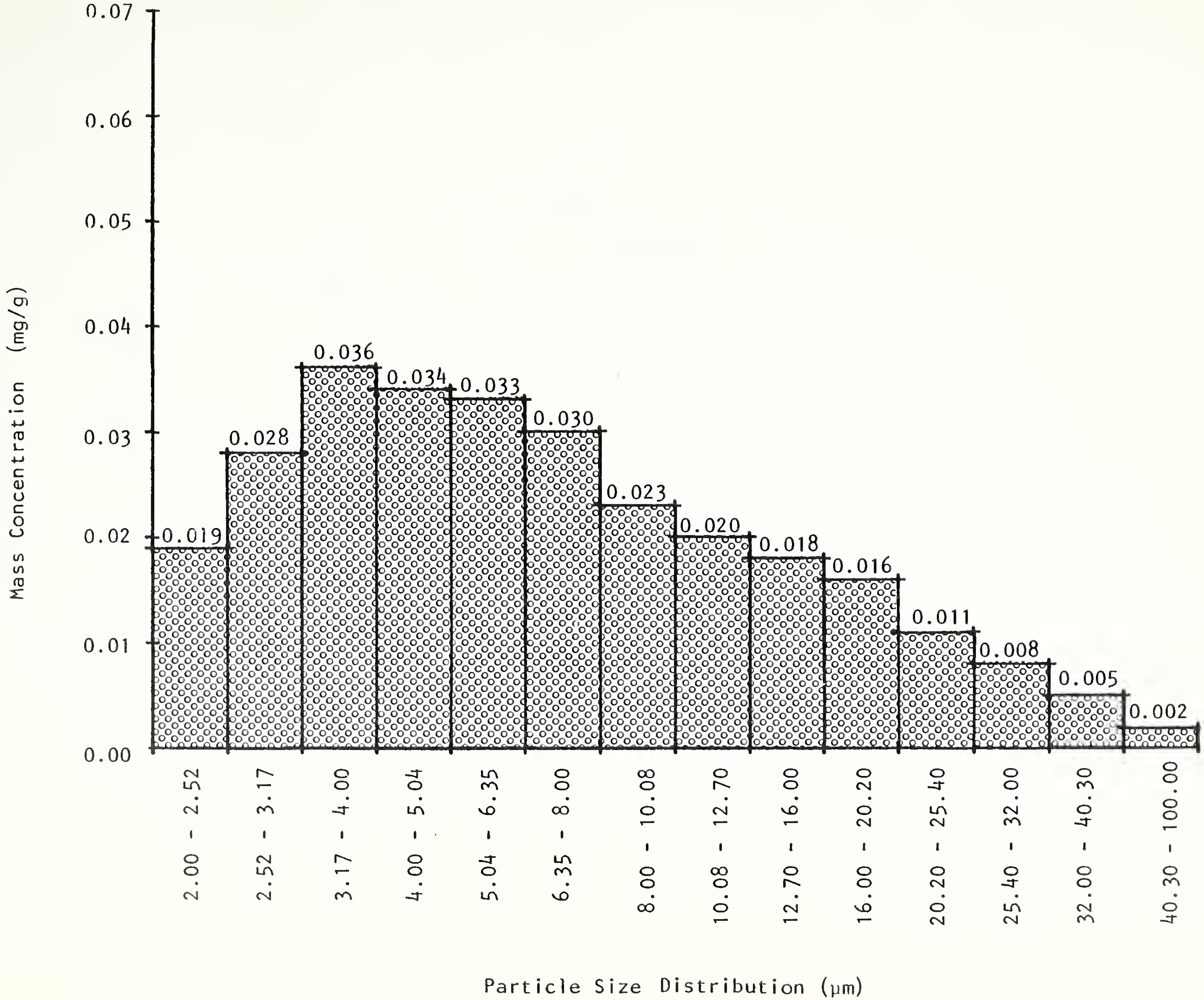
Mass Concentration - Particle Size Distribution
Mill I
P_3



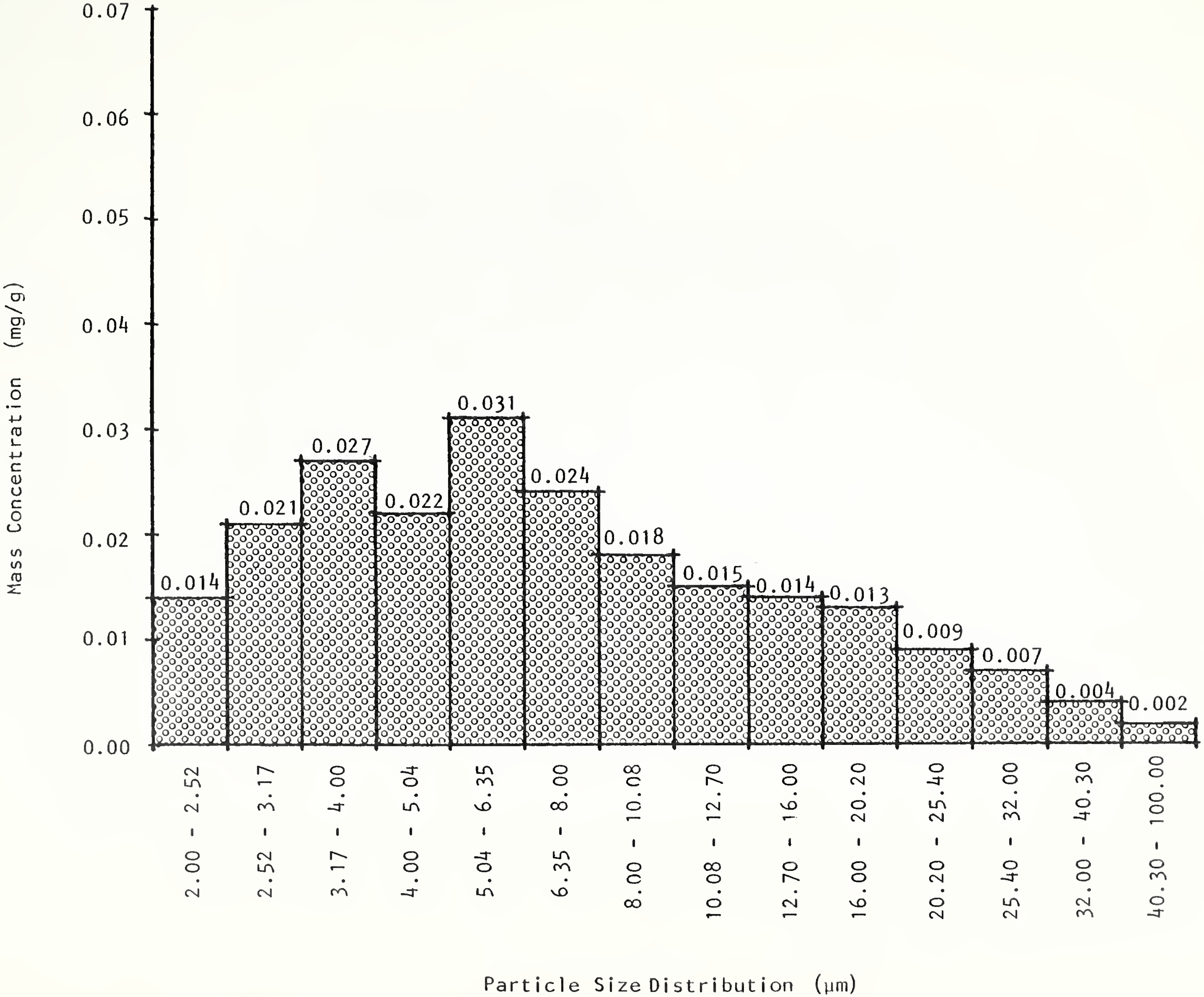
Mass Concentration - Particle Size Distribution

Mill I

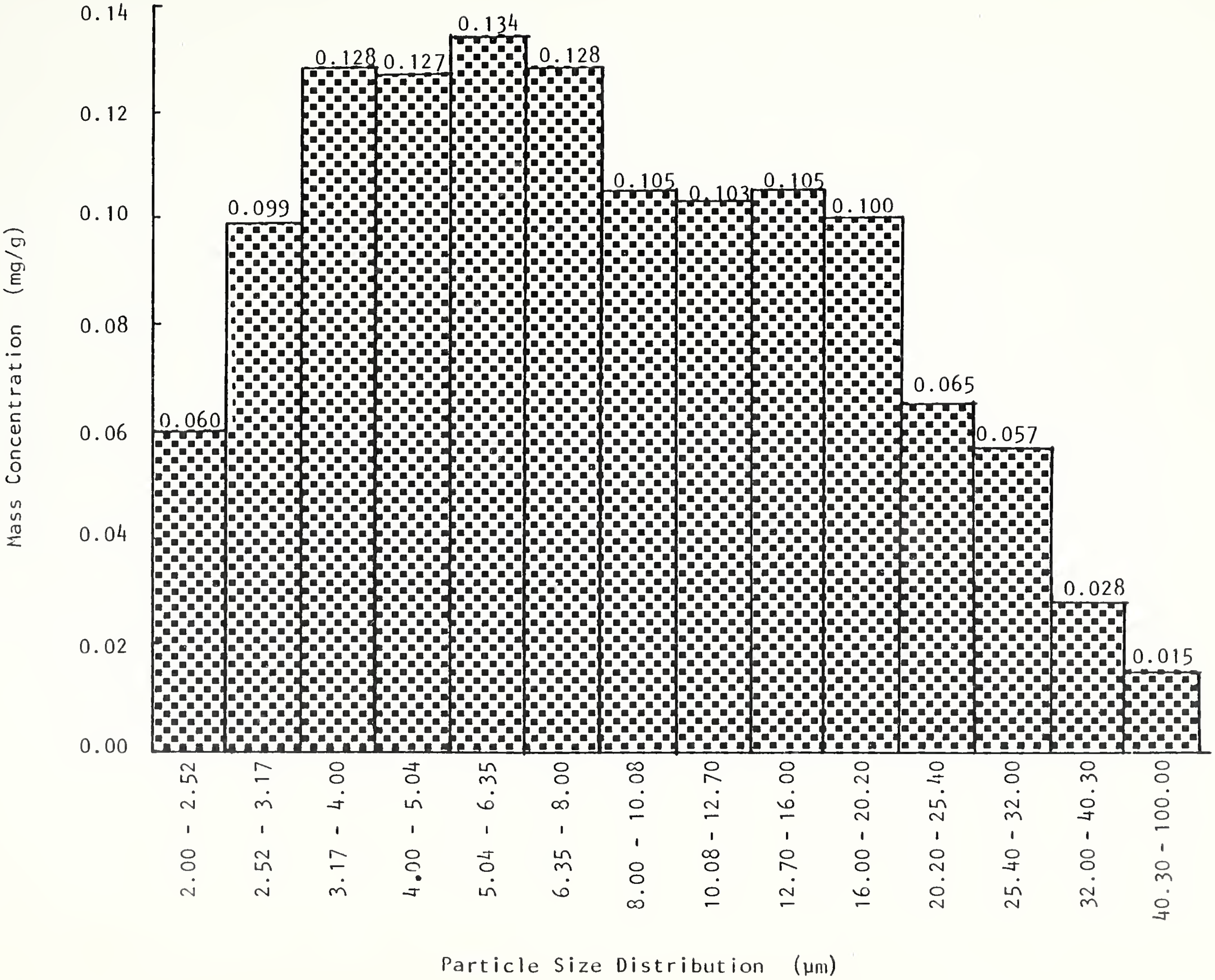
P_4



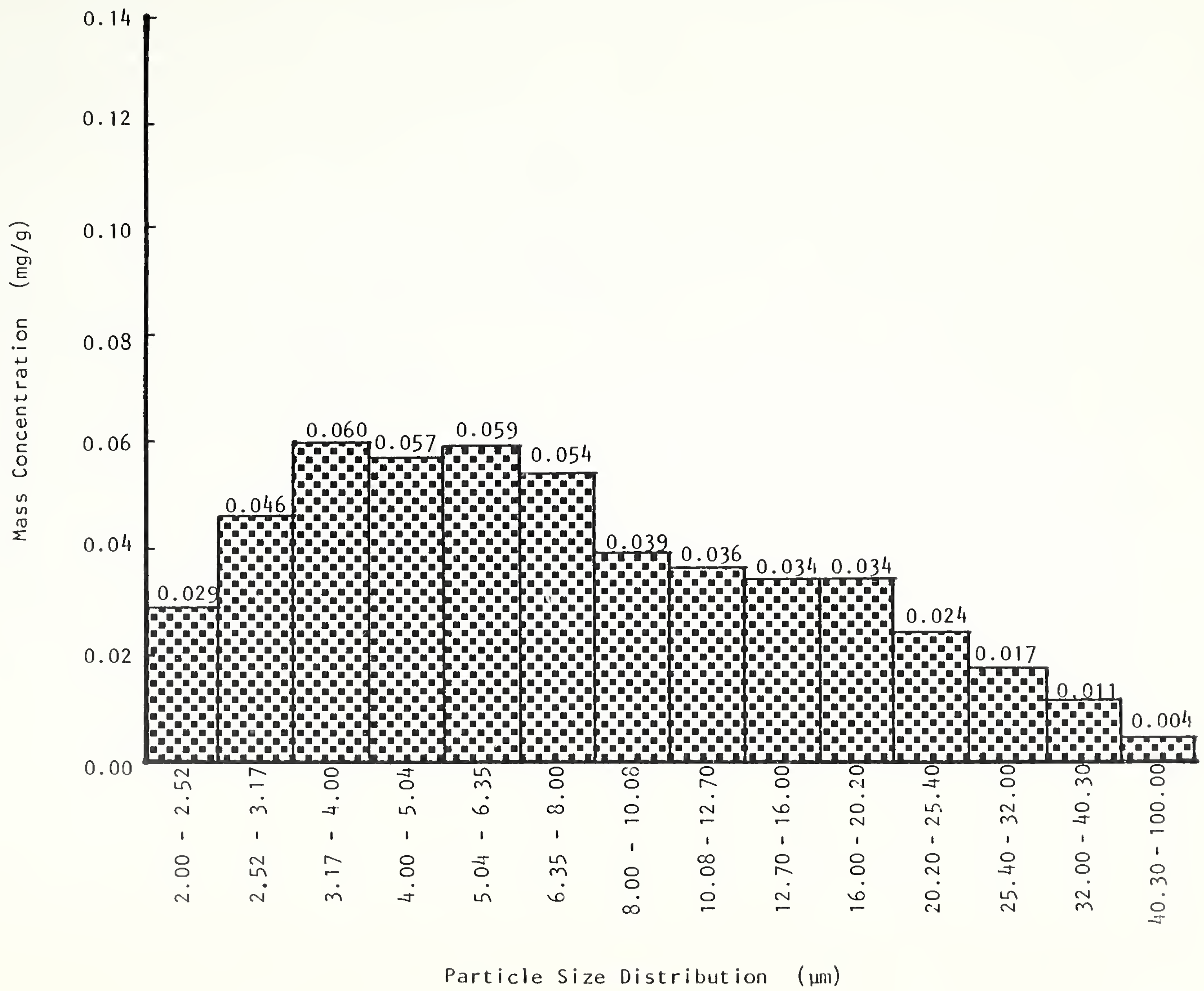
Mass Concentration - Particle Size Distribution
Mill I
P_5



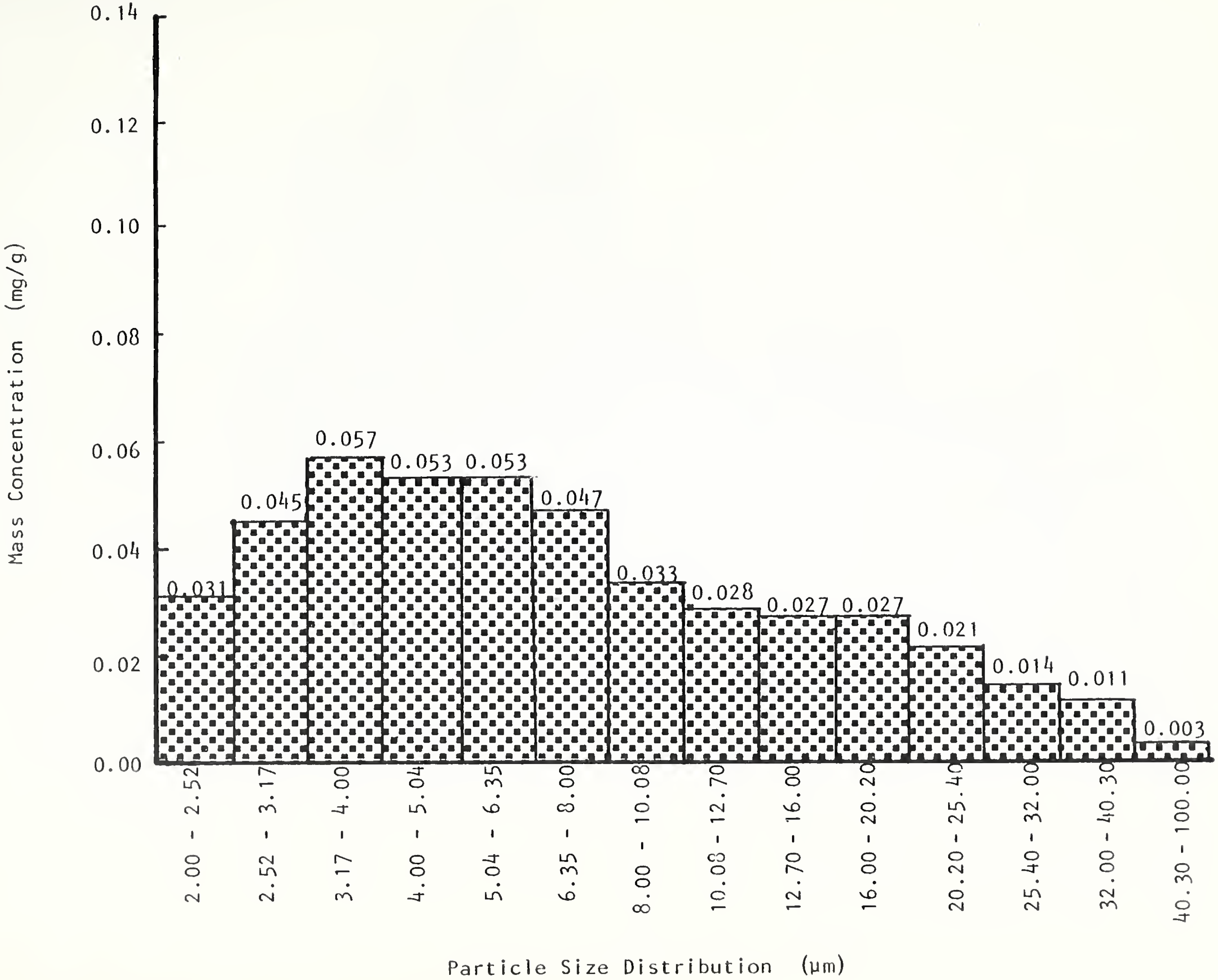
Mass Concentration - Particle Size Distribution
Mill J
P_0



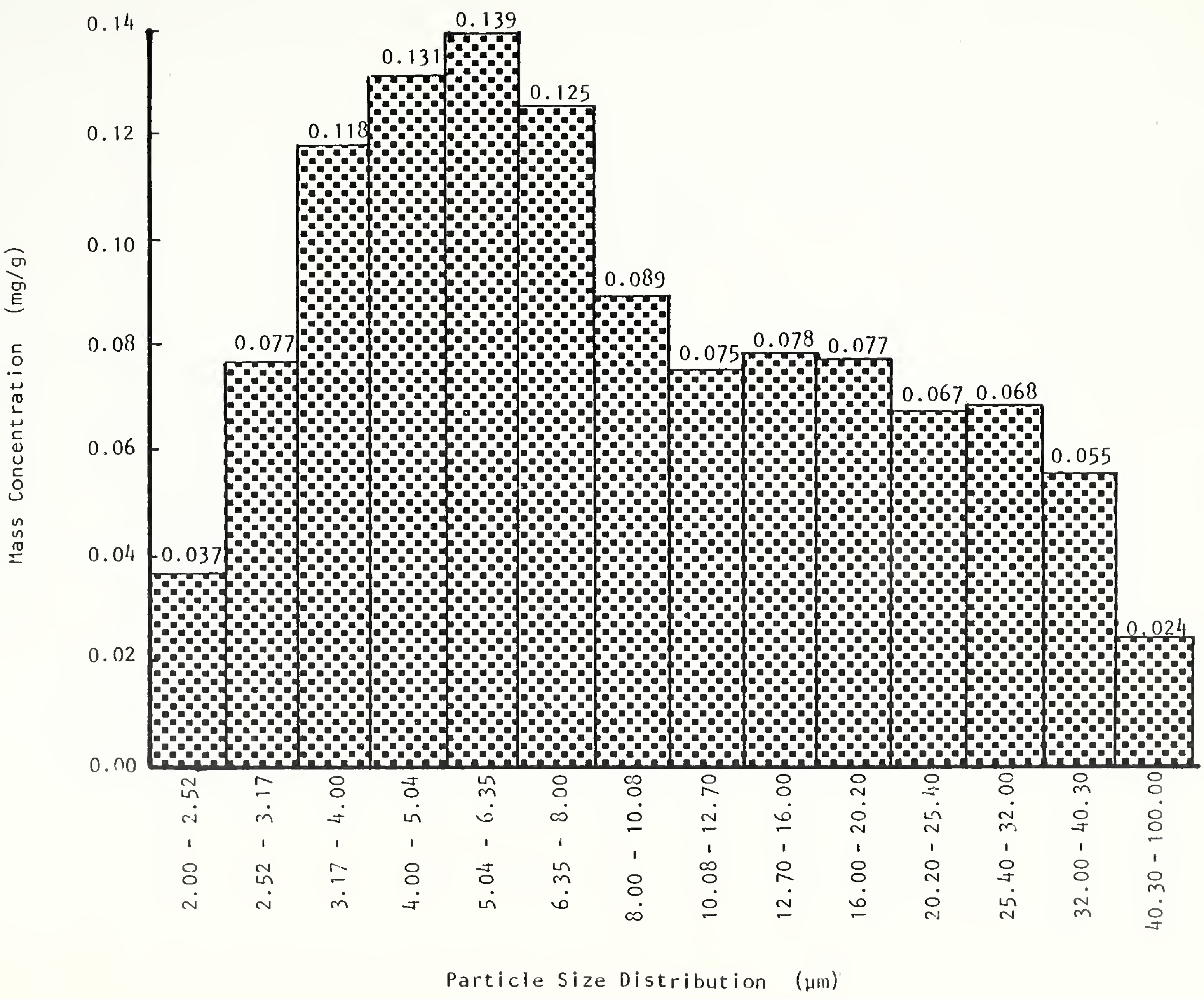
Mass Concentration - Particle Size Distribution
Mill J
P_2

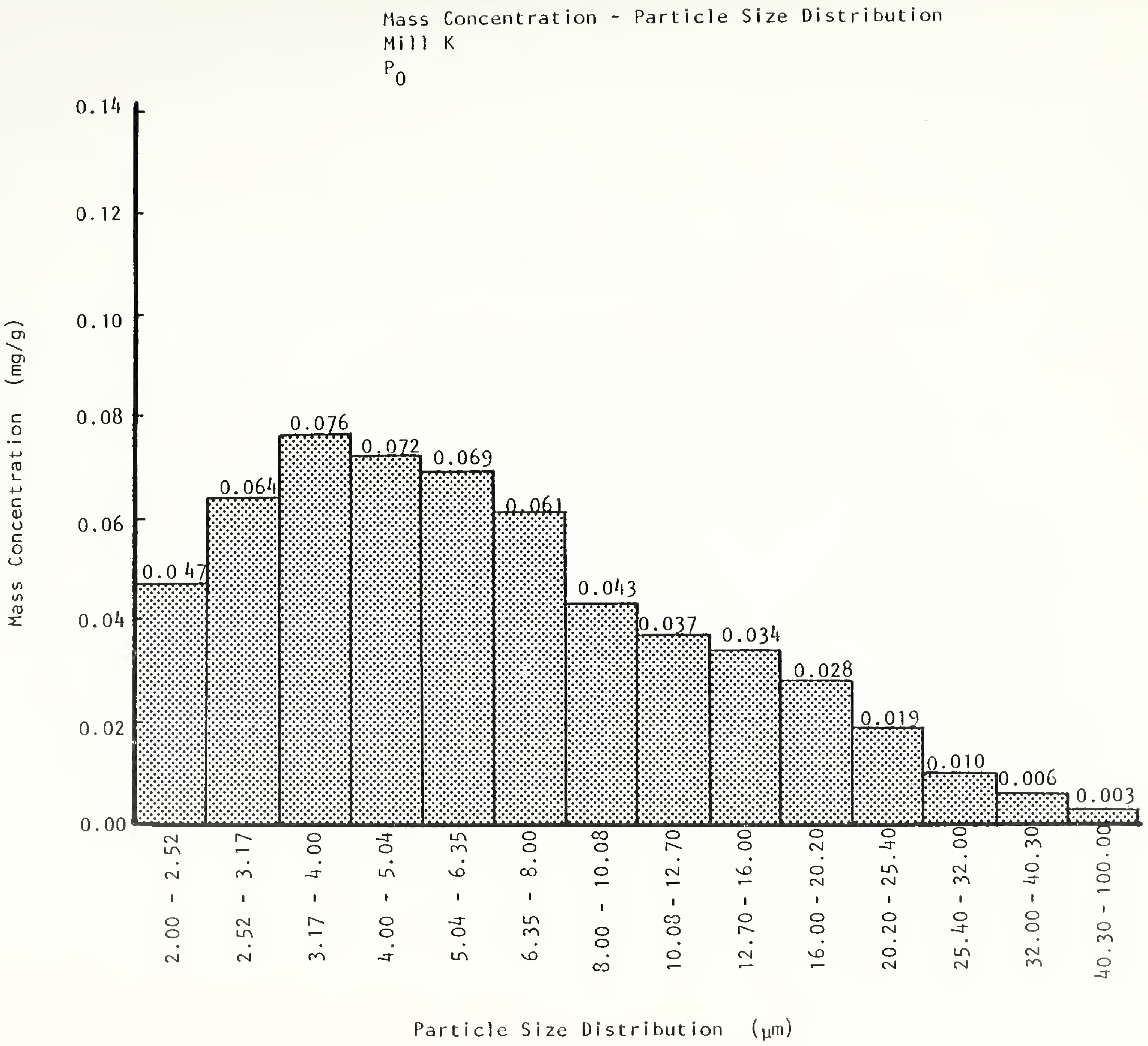


Mass Concentration - Particle Size Distribution
Mill J
P_3

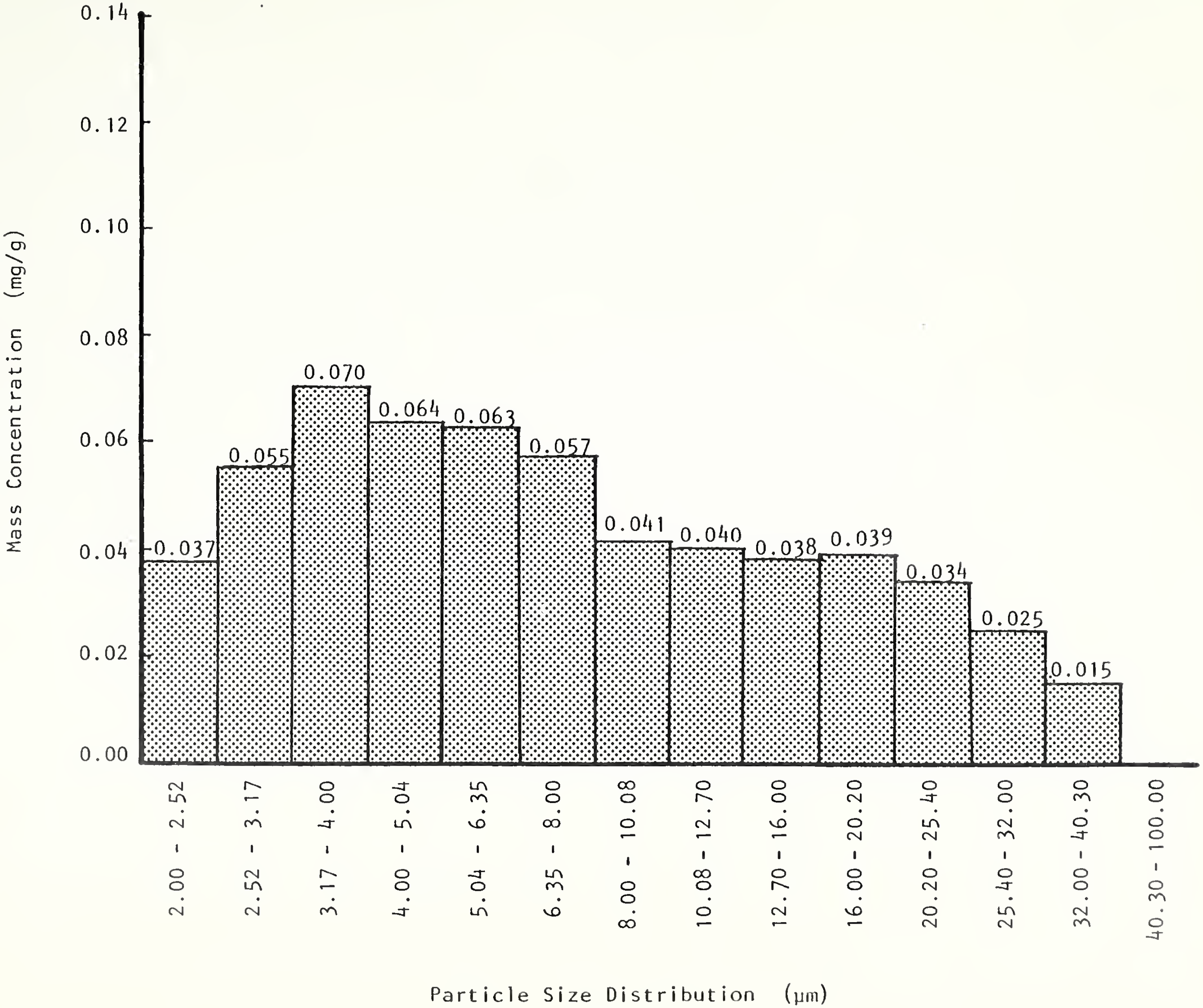


Mass Concentration - Particle Size Distribution
Mill J
P_4

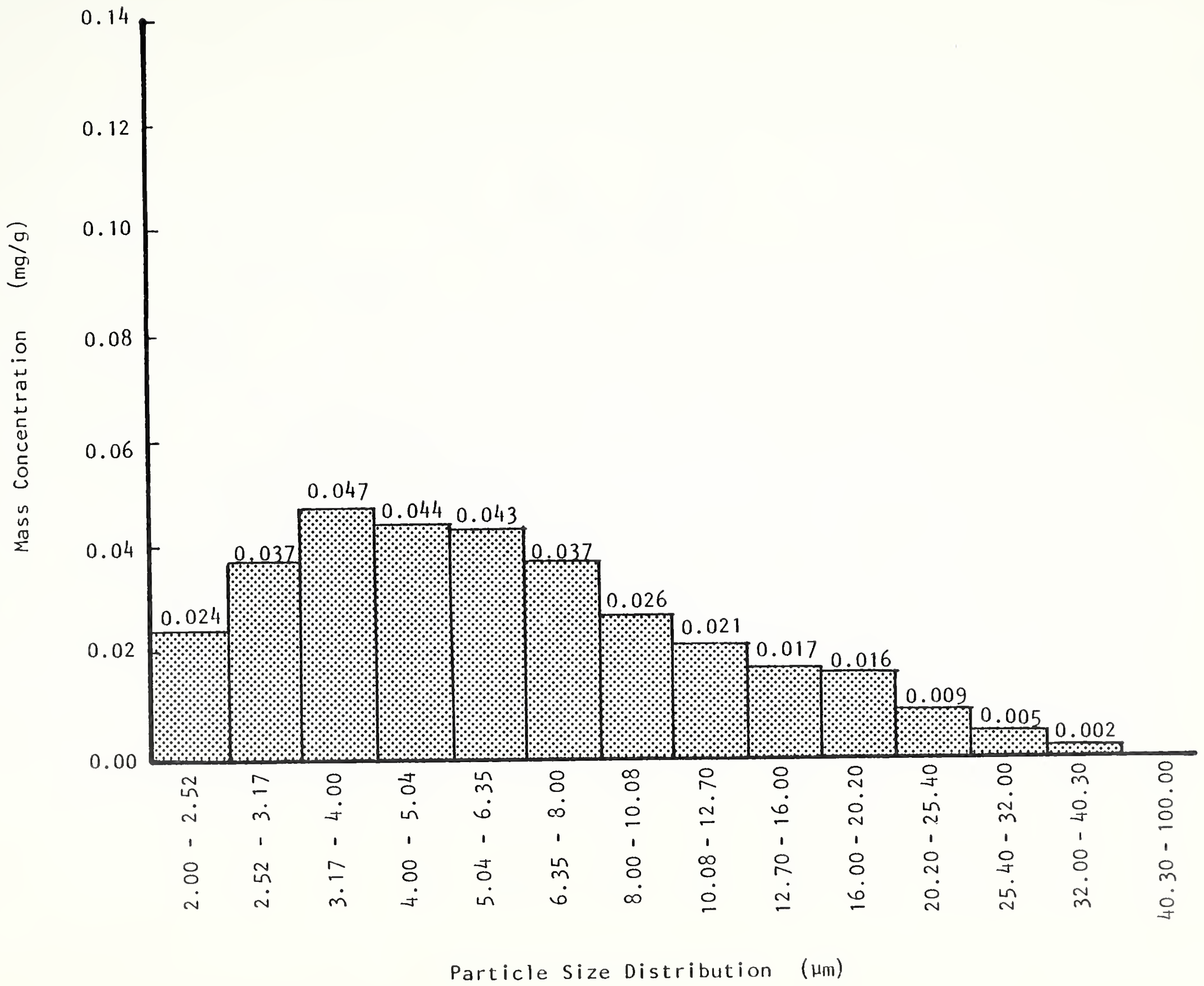



Mass Concentration - Particle Size Distribution
Mill K
P_0
Mass Concentration (mg/g)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0.047
0.064
0.076
0.072
0.069
0.061
0.043
0.037
0.034
0.028
0.019
0.010
0.006
0.003
2.00 - 2.52
2.52 - 3.17
3.17 - 4.00
4.00 - 5.04
5.04 - 6.35
6.35 - 8.00
8.00 - 10.08
10.08 - 12.70
12.70 - 16.00
16.00 - 20.20
20.20 - 25.40
25.40 - 32.00
32.00 - 40.30
40.30 - 100.00
Particle Size Distribution (μm)

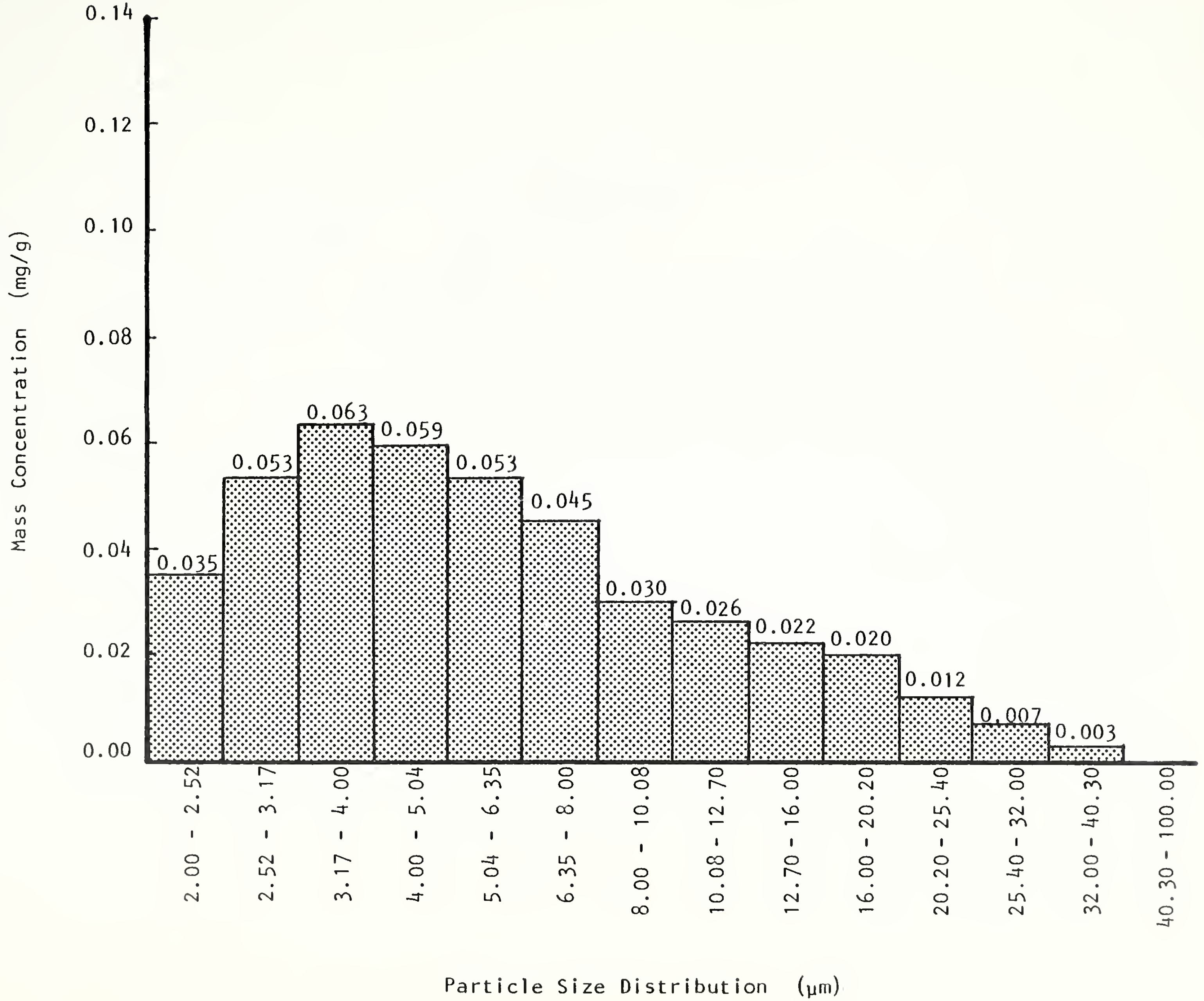
Mass Concentration - Particle Size Distribution
Mill K
P_1



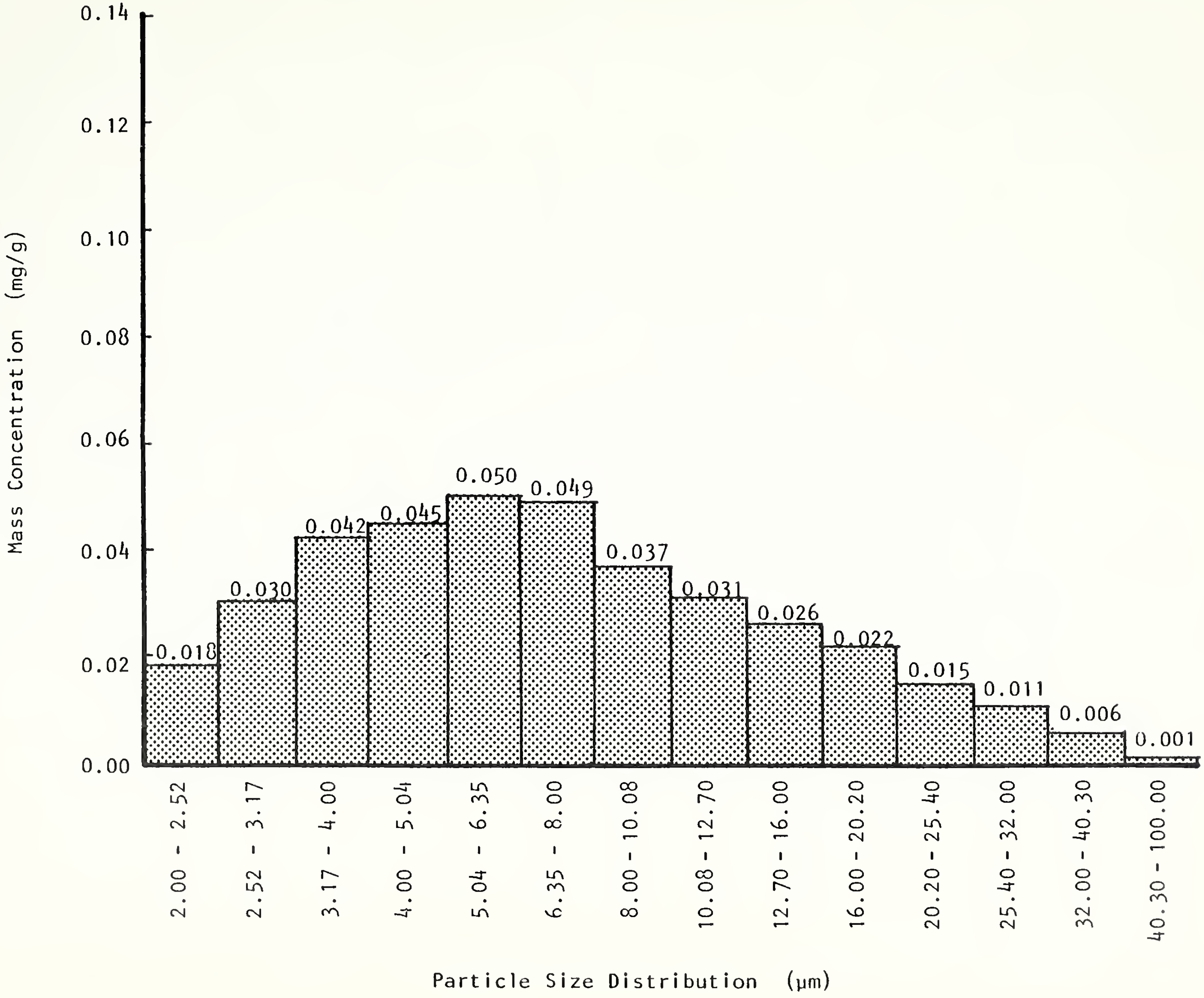
Mass Concentration - Particle Size Distribution
Mill K
P_2



Mass Concentration - Particle Size Distribution
Mill K
P_3



Mass Concentration - Particle Size Distribution
Mill K
P_4



APPENDIX B

MURRAY-CARVER, INC.

Executive Offices
P.O. Box 44152 – 14934 Trend Drive
Dallas, Texas 75234
Telephone 214-241-9440

Telex
73-2423 MURCO DAL

Cable: MURCO

June 27, 1979

Mr. Stan Clark, Associate Research Engineer
Texas A&M University
Food Protein Research & Development Center
Faculty Mail Service Box 183
College Station, Texas 77843

Dear Stan:

Further to our telephone conversation of today, we would give the following as a synopsis of what we are working on and what we have accomplished thus far in our work of reducing the dust emissions created by Carver machinery.

First, as I pointed out, we have made a considerable investment in research and development for improving the efficiency of our machinery while trying to alter the machinery to meet higher emission standards, both from sound and dust standpoints. Among these investments is a vertical elutriator which we have used to pinpoint areas emitting the highest dust.

While we have found that most dust is emitted from the conveyors, lint cleaning equipment, delinters, shakers, etc., we have found that we can completely enclose our machinery and still have emissions from conveyors, rotor lifts, etc. which create more dust than our machinery.

We have pinpointed the Carver Lint Cleaner as a source of dust emissions and as a result have installed shields at openings, fabricated the lint cleaner out of heavier gauge material to help hold the shape through years of abuse, and re-designed the drive to assist in lowering the noise level. We have completely reduced the dust emissions from this machine.

In the delinting area we have totally enclosed all known areas that would permit dust to enter the air around the machine itself. However, by doing this we reduced or practically eliminated the efficiency of the machine. We have also had reports of fires that may or may not have been caused by the enclosure. We have altered the design, permitting air to enter the

Mr. Stan Clark
Texas A&M University
College Sta., TX
June 27, 1979 - Page 2

delinter, allowing the machine to operate and still reduce the particulate emissions. We are in the process of installing some of these shields which include enclosing the area between the feeder and the seed board, enclosing the area between the seed board and the delinted seed chute, and enclosing the area at the end of the gratefall where the saw cylinder rests on the linter frame. These have proven to be the source of any dust emissions from the delinter and by enclosing these we feel assured we can lower the level of dust emissions from the delinter to a realistic working level.

One of the by-products in enclosing these areas is that we have lowered the sound level of the linter appreciatively. In fact, the front of the linter went from 98 to 91 decibels and the sides from 95 to 90 decibels. These levels will be even lower with the addition of sound deadening material to the seals which we have installed for the purpose of reducing the dust emissions. With the seals mentioned above installed on the linters we believe we have lowered emissions from 1/2 to 1 milligram per cubic meter.

At this point in time we have only sealed one machine out of 33 at Sweetwater and are unable to determine exactly what level we have achieved by sealing this one linter. We are manufacturing parts to completely enclose the remaining linters and when this work is completed we should have more information for the air emissions. From the standpoint of air emissions we are working with a series of air hood pick-ups over the shakers to eliminate the loose dust emissions created by the shaking process. This still is in the preliminary stages and we would prefer finding an alternate method to do this since this type of method would require an additional fan which, of course, means added horsepower which we are also trying to eliminate.

We do have some photographs of the seals that we have talked about but unfortunately at this time they are not in the office and as soon as I have these from Larry Allen and Jim Orr we will send you prints, which should be following in a few days.

As a personal note to you, Stan, contrary to what may be the thoughts in the industry, we are diligently trying to help the industry in reducing horsepower, dust emissions, and sound pollution created by our machinery, and doing this at a time when profits on our machinery are reduced through inflation, created by heaven knows what.

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Texas A&M University
College Sta., TX
June 27, 1979 - Page 3

This outline can be followed by a more specific reply if you desire. However at this point in time we can only say that we are working and altering designs for more efficient measures. Although we feel confident that we will accomplish what we are trying to do we know that more changes are going to be required.

Best personal regards,

MURRAY-CARVER, INC.

D. H. Petty
Manager Carver Sales
Dallas District

DHP:hr

cc-Mr. J. C. Orr
Mr. G. A. Fountain
Mr. P. A. Gerard

APPENDIX C

CLASSIFICATION OF OIL MILL DUST SOURCES AND SUGGESTIONS FOR CONTROLS

S. P. Clark

Technology for oil mill dust control is definitely in a state of development as many new ideas are being tried. Part of the solution of any problem is description and definition of it. This is an attempt to define the problem of oil mill dust by classification of the sources of dust. Similar control measures then may be applicable within each classification.

Displacement of Air and Suspended Dust

Inside all machinery in the mechanical pretreatment and meal handling departments of oil mills, air is in turbulent motion and dust is in suspension. As new solids material is fed into such machines, air is displaced into the surrounding air and the displaced air carries dust with it. Control of this dust can be achieved by venting displaced air only through dust control systems.

Examples of machines and emission points are screw conveyors with loose covers, open feed or discharge spouts, or open ends; bins or hoppers without covers, with loose covers, or covers without vents into a dust control system; linter seed rolls, baling presses, beaters, mixers, bucket elevators.

Control can be achieved on all of the above machines and similar ones, by providing tight covers which will not allow air and dust out except through dust control systems. Dust control systems have not been completely developed but types which are suggested may be called dynamic and static. A dynamic system vents all air and dust into a negative pressure collecting system from which air is discharged to atmosphere only

through air cleaners such as cyclones, filters, scrubbers or electrostatic precipitators. Direct aspiration of a machine to provide a negative pressure inside it to control air/dust flow may be the most common example of a dynamic system.

A static-system is typified by a filter attached to a bin so that all air displaced from the bin must pass through the filter.

Neither control system suggested is without problems and costs, but the principle of dust control is sound - which is control at the source. Directed flow of air from the outside into process machinery which is equipped with air handlers, such as linters, has been suggested as a means of dust control. This author believes that such control may be helpful but only as auxiliary and not primary control. Primary control should be at the source as described.

Falling Materials Without Enclosure

A second category of dust emissions, much like the previous one, is created by material falling from one machine to another or onto a pile, without any enclosure to stop the movement of air and contain the dust. Examples are: materials feeding onto screens, and materials falling from one screen to the next, in seed cleaners, safety shakers, huller shakers, purifiers and hull beaters. Additional examples are seed unloading into dump pits, additions of seed or hulls to storage piles, and bulk hull and meal loading operations.

This is a difficult type of emission to control because no enclosure is on hand to contain the dust and direct the air and dust through control systems. Control will probably require that enclosures of some kind be developed which will allow control to be achieved by the means suggested under the first category.

Discharges from Positive Pressure Systems

Most solids processing equipment without aspiration is under slight positive pressure. If it were not, air and dust would not be emitted. However, this category refers to systems such as positive pressure pneumatic conveyors which should be designed to contain all air and dust until the air is discharged through dust control devices such as cyclones. Cottonseed hullers and mills grinding meal or other materials may fall into this emissions category. Leaks in blow lines, cyclones, fans or mills in such systems can discharge great amounts of air and dust into ambient air at locations which have no dust controls. The obvious means of control for these emissions is repair of leaks.

Dust may also come from such systems if the cyclones are inefficient or if the feeders or conveyors discharging solids from the system allow air to leak out. Control may require modification of the system.

If a conveying system can be converted from positive to negative pressure then outward leaks will be eliminated and dust emissions will be concentrated at the fan discharge.

Outside Air Pulled Into Buildings

Outside air may be classed as a fourth dust source category because obviously if the outside air is above the desired levels of particulate matter, when this air is pulled into buildings by process fans, unless this air is filtered, the air inside the buildings will have the particulates in incoming air added to particulates generated inside the buildings.

One of the principal sources of dust in outside air is air discharging from the tops of positive pressure cyclones or from fans on negative pressure systems. These emissions are usually made outside the buildings but unless there is a reliable wind to blow them away, they may be recycled

back into the building. Controls which have been tried are improved cyclones, filters and wet scrubbers. They probably all should be considered when seeking a solution to this problem.

Seed unloading and hull or meal storage and loading operations may be dust sources. Choke ups on pneumatic conveying systems may contribute. Your neighbors' cyclones and other operations may also be a dust source, as from a neighboring grain elevator or feed mill. Natural sources such as dust storms contribute. Controlling any of these sources is difficult.

One should not forget that your dust discharged into outside air may likewise become a source of dust pulled into your neighbors' buildings.

Dust in outside air usually tends to settle on building roofs and on the yard where it may be resuspended by wind action and traffic. Paving and sweeping yards and sweeping roofs helps in control.

Resuspension of Inside Dust

Most oil mills can be observed to have settled dust on top of equipment and building structural members. Vibration and air movement tends to resuspend this dust in the air, and therefore it should be removed periodically. OSHA standards discourage the use of compressed air "blow downs". Vacuum systems may be able to deal with this problem. However, careful use of compressed air will probably continue to be necessary, followed by sweeping or vacuum pickup of dust. Of course, as other control measures come into use and become refined, settlement of dust will be lessened, because less dust will be in the air, and resuspension of dust will be proportionally decreased.

Presented to Oil Mill Operators Short Course
College Station, TX
April 10, 1979